Tactical Tomahawk Weapon System
Developmental/Operational Testing

Testing a System of Systems

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Report Documentation Page

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Agenda

- Background
- DT/ OT Test Structure
- Lessons Learned
- Summary
• Tomahawk is an integrated set of independently procured elements
• The Tomahawk Weapons System has been using modeling and simulation (M&S) for development, test and sustainment since the programs inception
• The Tomahawk program has been practicing M&S management and verification, validation, and accreditation (VV&A) since 1983
Tomahawk Development History

- **1983**: Block I
  - Conventional Land Attack
  - Single Target
  - Vertical Launch, Vertical Dive

- **1988**: Block II
  - Multiple Targets (TLAM-D)

- **1993**: Block III
  - GPS, Improved DSMAC, Increased Range, Time Of Arrival, Afloat Planning System (APS)

- **2004**: IOC
  - Iraqi Freedom
  - Enduring Freedom
  - Allied Force
  - Desert Fox
  - Desert Strike
  - Deliberate Force

- **2004**
  - Increased Flexibility
  - Increased Responsiveness
  - Improved Lethality
Blk IV Mission Flexibility and Responsiveness

Preplanned Mission
Missile Retargeting
Loiter Capability

First Preplanned Waypoint
CG/DDG

SSN/SSGN

Secondary Targets
Guidance Waypoints
Flex Points
Loiter Pattern

Primary Targets
GPS

DSMAC Map
BDI Image

Health & Status

TSN UHF SATCOM
(5 kHz UHF DAMA)

GPSTSN
UHF SATCOM
(5 kHz UHF DAMA)
Tomahawk Command and Control System

Strike Tasking
- Mission Objectives to CMSA / APS / C2

Mission Planning (TMPC / APS)
PTW & DIWS
Target Development and Weaponeering

DIWS & TPS
Route Planning and Evaluation

TPS & MDS
Mission Verification

Mission Distribution System
- MDU / DTD / TCI

Strike Execution
- Strike Coordination Aids
- Missile/Mission Inventories
- Post Strike Analysis/Evaluation

Strike
Tomahawk Communication Information Infrastructure

GBS - Global Broadcast System (SHF)
DSCS - Defense Satellite Communication System (SHF)
MILSTAR - Military Strategic Tactical Relay (EHF)
FLTSAT, UFO - Fleet Satellite, UHF Follow On (EHF, UHF)
NCTAMS - Naval Computer & Telecommunications Area Master Station
DISN - Defense Information Service Network

DATA SOURCES
DIWS TPS MDS
NCTAMS
GBS GROUND STATION
GBS
DSCS
MILSTAR
FLTSAT, UFO
DIWS TPS MDS
Targets Missions Media
Other Imagery/Data Sources
Tasking

DISN
C2 SITES
PIERSIDE TCI UPDATE (STU III)
BULK TCI DISTRIBUTION
APS
ATWCS
SSN WCS
Tomahawk Strike Network is composed of the following elements:

- **SATCOM Network Controller**: Establish network, disestablish network, control message flow.
- **Tomahawk Strike Coordinator**: Plan strike, plan communications.
- **Tomahawk Command Node**
- **Tomahawk Platforms**
- **Tomahawk Missile/Strike Controllers**: Monitor strike, retarget missiles.
- **Tactical Tomahawk Missiles**: Report health/status, acquire BDI images, execute retargeting.

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**Diagram Notes**:
- Tactical Tomahawk Missiles are connected to Tomahawk Strike Coordinator and Tomahawk Command Node.
- SATCOM Network Controller interacts with the Tomahawk Command Node.
Test Challenges

- Satellite communications access
- Communications network loading
- Simulation capability evolution
- Multiple launch platforms
- Geographically dispersed assets
- Test coordination communications
- Large strike - hundreds of missiles in the air
Simulations Used for Test

- Mission Validation System Tomahawk Engineering Simulation/ Monte Carlo (MVS TES/ MC)
- Mission Validation System/ Register Level Simulation (MVS/ RLS)
- Tactical Simulation (TACSI M)
- Tomahawk Advanced Flight Simulation/ Monte Carlo (TAFS-T/ MC)
- Missile Communications Simulation (MCS)
- Tactical Tomahawk Multi-Missile Communications Simulator (TTMMCS)
- Shipboard Environment & Missile Simulation with Functional Ground Test (SEMS-SHA)
- Land Attack Systems Integration Laboratory (LASI L)
- Register Level Simulation, Tomahawk Missile in the Loop (RLS/ TMI L)
TECHEVAL Test Events

- **Shipboard Weapon Control Test Events**
  - SWEF - Land Based TTWCS/PCMDS Testing
  - Surface Combat Systems Testing - Pier side
  - Surface Combat Systems Testing - At-Sea
  - LASIL - Land Based TTWCS/PCMDS Testing

- **Submarine Weapon Control Test Events**
  - CCSL Testing - Land Based
  - Submarine Combat Systems Testing - Pier-side
  - Submarine Combat Systems Testing - At-Sea

- **Command and Control Test Events**
  - Mission Planning
  - Strike Planning

- **Flight Test Events**

- **Multi-Ship End-to-End Test Events**
  - Multi-Ship End-to-End Lab Test
  - Battle Group End-to-End At-Sea Test
  - Full Test Configuration Battle Group End-to-End At-Sea Test
    - Operational Test Dry-Run (OTDR)
## OT Test Configuration

<table>
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<tr>
<th>OT Event</th>
<th>Test Asset</th>
<th>USS STETHEM</th>
<th>USS TUCSON</th>
<th>TTGP</th>
<th>EWTGPAC</th>
<th>STT</th>
<th>NSWC DD</th>
<th>NUWC Npt</th>
<th>ATWCS Ship</th>
<th>AOSDLANT</th>
<th>NSWC Corona</th>
<th>UHF SATCOM</th>
<th>EHF SATCOM</th>
<th>TTMMCS</th>
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</table>
DT-IIC End-to-End @ Sea

Satellite Comms

- **UHF:** TSN, SP, MDU, MPR
  - Voice, Chat, Tracks
- **EHF:** SP, MDU, Voice, MPR
  - Chat, Tracks

Command and Control

- **WPC** (TACSIM)
- **TSC/SACC/Strike Controller** TACTRAGRUPAC
- **TTMMS-DT** APL
- **NSWC/IHD** (TAFS/TMIL)

Firing Units

- **DDG-63** (Tactical Mode + TMEUs/MK 96s)
- **NSWC/DD** (TTWCS/ATWCS in tactical mode/IDSIM)
- **NUWC/NPT** (TTWCS in tactical mode/MK 101)
- **TBD SSN** (Tactical Mode + Mk 101)
**OTDR Test Goals/ Participants**

**Test Goals:**
- Comprehensive System End-to-End Test
- Mimic OT 96 HR Scenario
- Demonstrate System Functionality from Mission Planning to Target Engagement
- Exercise External Interfaces in a simulated tactical environment

**Satellite Comms**

- **UHF:** TSN, SP, MDU, MPR
  - Voice, Chat, Tracks

- **EHF:** SP, MDU, Voice, MPR
  - Chat, Tracks

**Command and Control**

- **NSWC Corona** (Contact Broadcast)
- **AOSDLANT / WPC** (Mission Planning)
- **TSC/LAC/SC (TFCC)**
  - Alt SC, SACC (PCC)
- **TTMMCS**
- **STT, HI** (Alt SC)
- **TACTRAGRUPAC**

**Firing Units**

- **DDG-63** (Missile Controller)
  - (Tactical Mode + TMEUs, MK96, M683s)
  - **USS NSWC** (TTWCS in tactical mode + VLSS)
  - **USS NUWC** (TTWCS in tactical mode/ MK 101)
- **SSN 770** (Missile Controller)
  - (Tactical Mode + Mk 101 Sim)
OT-11C End-to-End @ Sea

Satellite Comms
- NSWC Corona (Contact broadcast)

Command and Control
- CMSAPAC
- TSC/SACC/Strike Controller
- TMMMS-OT
- STT, HI (Alt SC)
- TACTRAGRUPAC
- Forward Observers (Satcom voice)

Firing Units
- DDG-63 (Tactical Mode + TMEUs/MK 96s)
- NSWC/DD (TTWCS in tactical mode + IDSIM)
- NUWC/NPT (TTWCS in tactical mode/ MK 101)
- TBD Shooter (Tactical Mode + Mk 101 Sim)
- ATWCS Shooter (Training Mode)
Lessons Learned

- All interfaces, external and internal must be well documented and under configuration management
- Don’t assume that legacy performance is as advertised or documented - characterized, model & simulate
- Planning must start years in advance
  - Some simulations took 4 years to define, develop and accredit
  - Live asset scheduling
- M&S MUST be used to adequately develop, test and sustain large scale complex systems
- M&S MUST have advocacy for the program to be a success
  - Resources
  - Policy
- A robust M&S VV&A process essential
  - Established by policy
  - Needed to support OTA accreditation
  - M&S accreditation finds software defects
  - Accredit with the end-user in mind
  - Establish and promote site accreditation
Summary

- Tomahawk continues to pioneer the use of M&S in large scale systems of systems testing
- VV&A applies to the whole test configuration – not just traditionally defined M&S
  - Test sites
  - Test configurations

Bottom Line: You MUST use M&S to test complex systems but... the limitations and characteristics of the M&S must be clearly understood in order to get accurate results
Acronym List

- APS - Afloat Planning System
- ATWCS - Advanced Tomahawk Weapons Control System
- AUR - All Up Round
- BDI - Battle Damage Indication
- BDII - Battle Damage Indication Imagery
- CCSL - Combat Control System Laboratory
- CMSA - Cruise Missile Support Activity
- DAMA - Demand Assigned Multiple Access
- DISN - Defense Information Service Network
- DIWS - Digital Imagery Work Station
- DT - Development Testing
- DTD - Data Transport Devices
- DSCS - Defense Satellite Communications System
- DSMAC - Digital Scene Mapping Area Correlation
- FLTSAT, UFO - Fleet Satellite, UHF Follow On
- GBS - Global Broadcast System
- GCCS-M - Global Command and Control System Maritime
- GPS - Global Positioning System
- IOC - Initial Operational Capability
- LASIL - Land Attack Systems Integration Laboratory
- MDS - Mission Distribution System
- MDU - Mission Data Updates
- MIDS - Modernized Integrated Database
- MILSTAR - Military Strategic Tactical Relay
- NIMA - National Imagery and Mapping Agency
- NCTAMS - Naval Computer & Telecommunications Area Master Station
- OT - Operational Testing
- PCMDSD - Personal Computer Mission Distribution System
- PTW - Precision Targeting Workstation
- SWEF - Surface Warfare Engineering Facility
- TCI - Tomahawk Command Information
- TC2S - Tomahawk Command and Control Segment
- TCOM - Terrain Contour Matching
- TPS - Tomahawk Planning System
- TSN - Tomahawk Strike Network
- TTMMCS - Tactical Tomahawk Multi-Missile Communications Simulator
- TTWCS - Tactical Tomahawk Weapons Control System
- WCS - Weapons Control System
Questions?