

Tactical Tomahawk Weapon System Developmental / Operational Testing *Testing a System of Systems*

Jeffrey S. Mayer

Naval Air Systems Command

Jeffrey.mayer@hanscom.af.mil

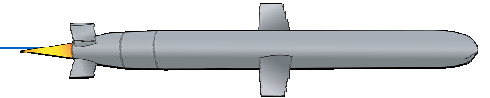
13 December 2005



Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 13 DEC 2005		2. REPORT TYPE		3. DATES COVERED 00-00-2005 to 00-00-2005	
4. TITLE AND SUBTITLE Tactical Tomahawk Weapon System Developmental/Operational Testing Testing a System of Systems				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Air Systems Command,Hanscom AFB,MA, 01731				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Modeling and Simulation Conference, 2005 Dec 12-15, Las Cruces, NM					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 22	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



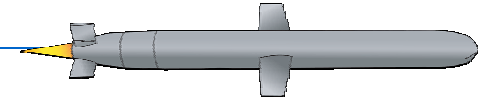
Agenda



- Background
- DT/OT Test Structure
- Lessons Learned
- Summary



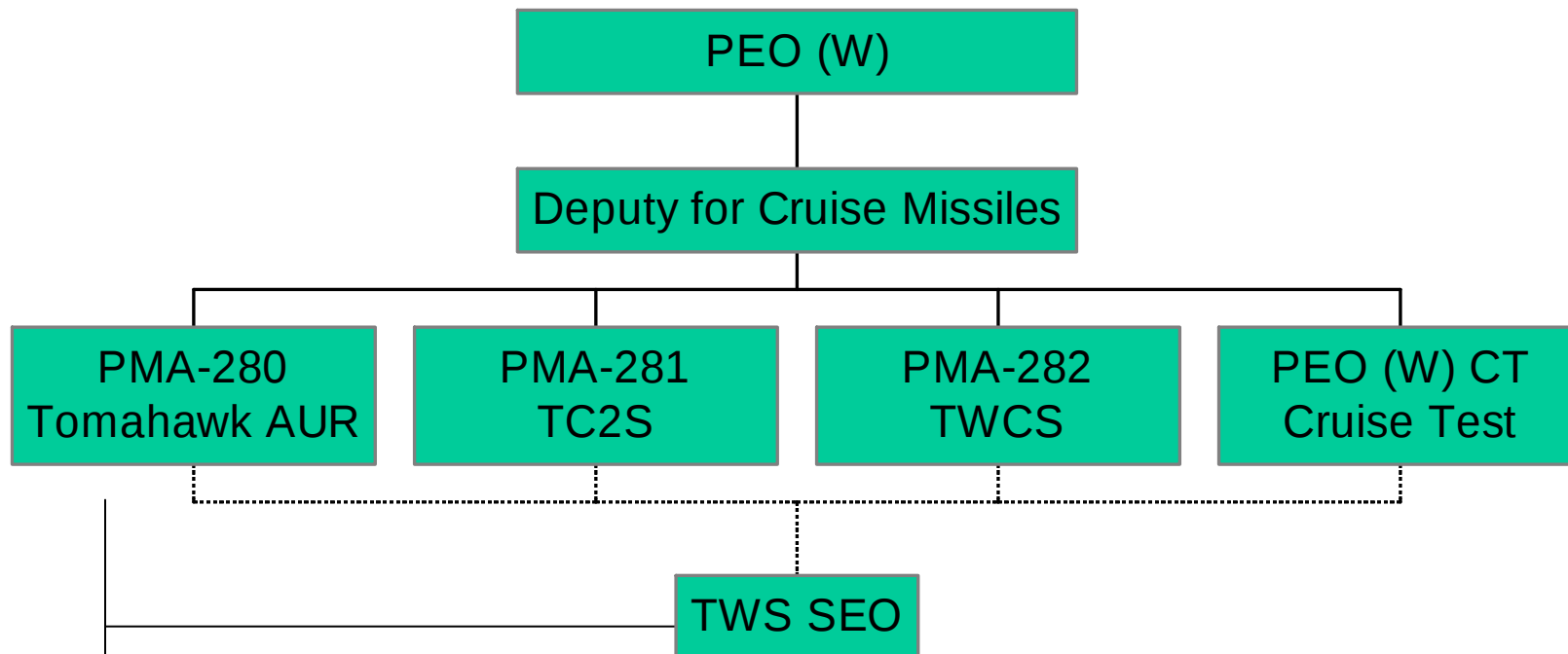
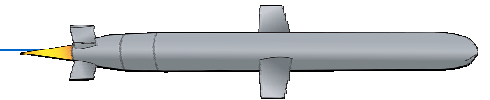
Background



- 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 Weapons System Organization



PEO (W) – Program Executive Office for Strike Weapons and Unmanned Aviation

AUR - All Up Round

TWS - Tomahawk Weapons System

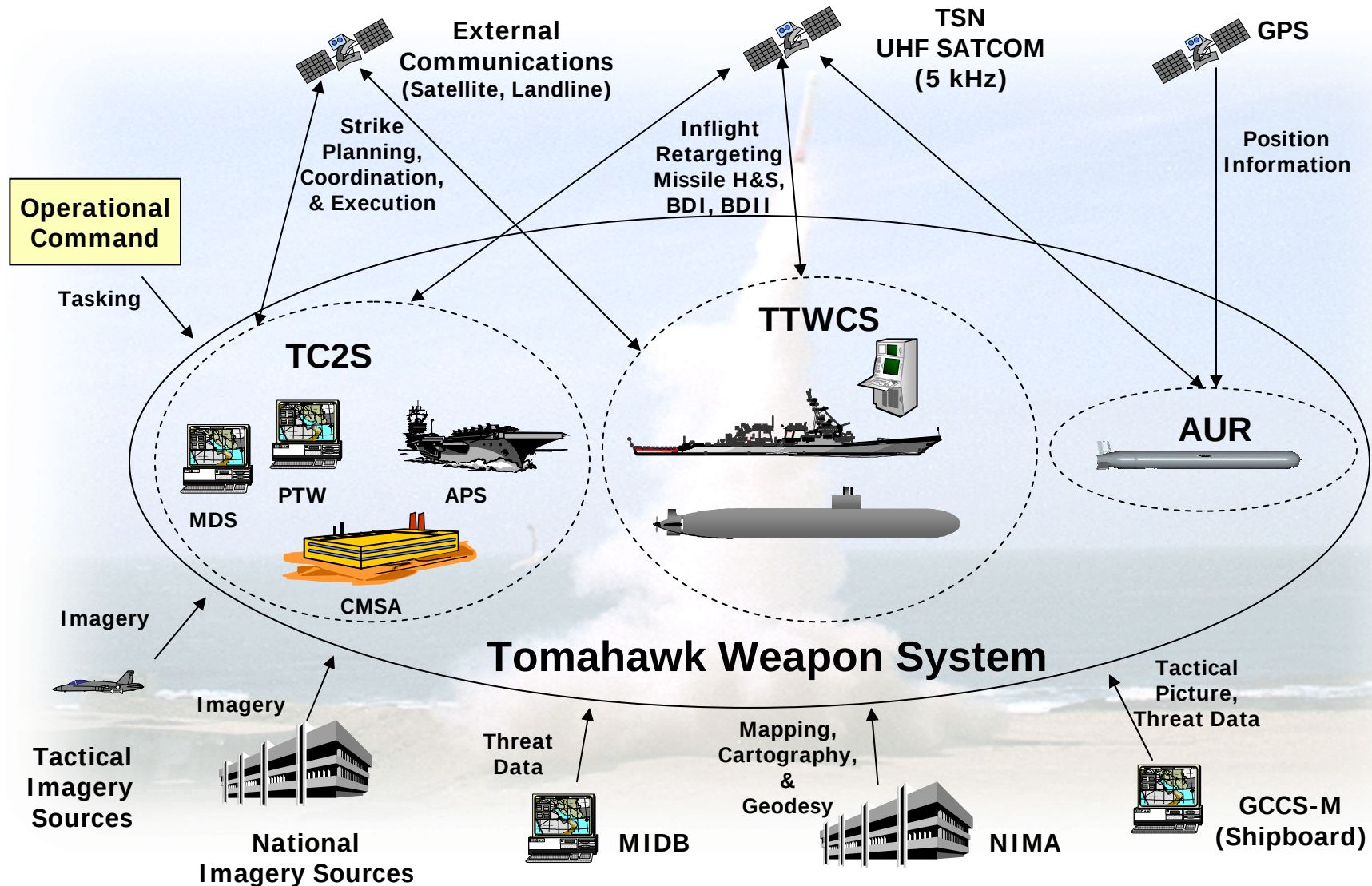
SEO - Systems Engineering Organization

TWCS - Tomahawk Weapon Control System

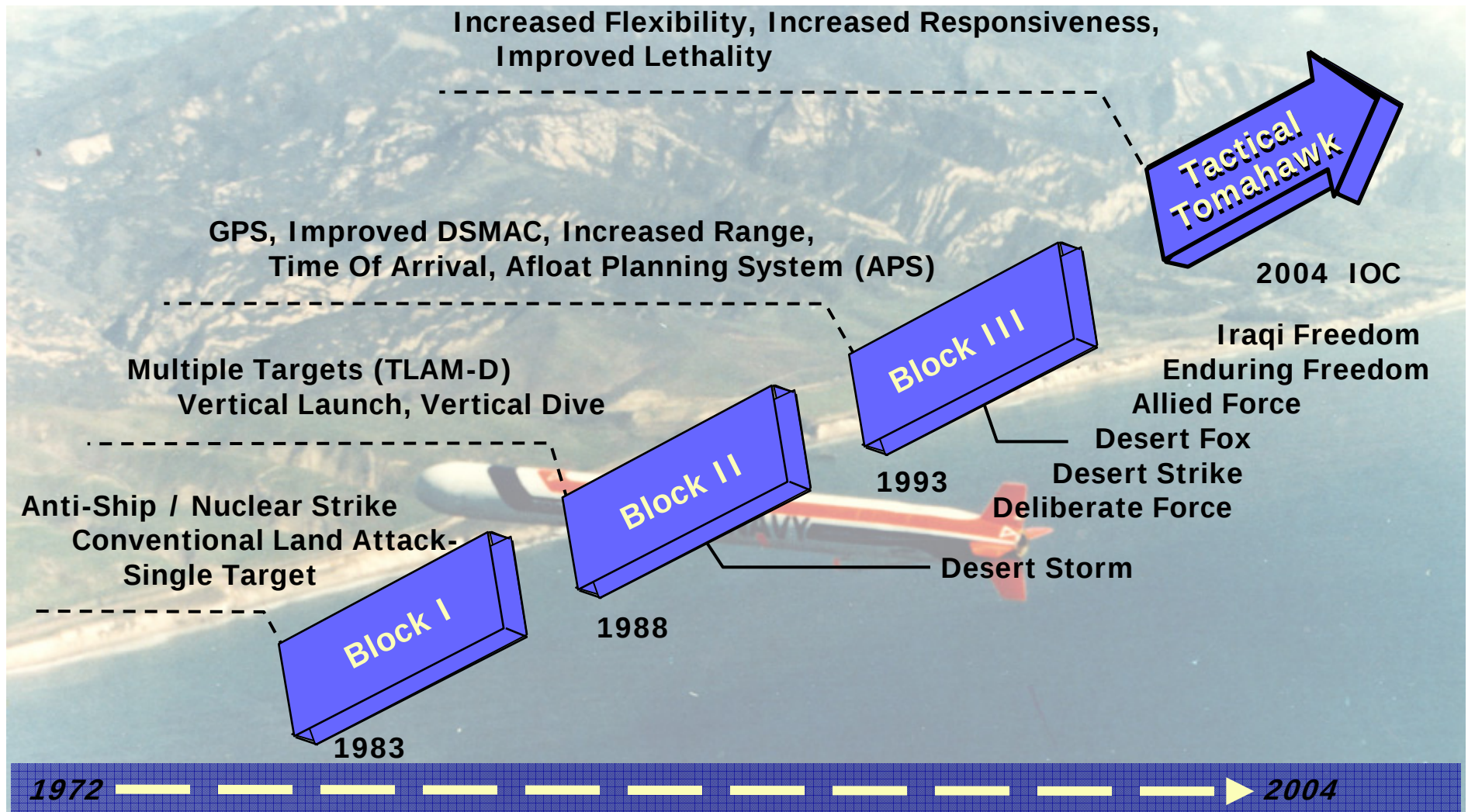
TC2S - Tomahawk Command and Control System

Note: Organization at time of test, has recently changed

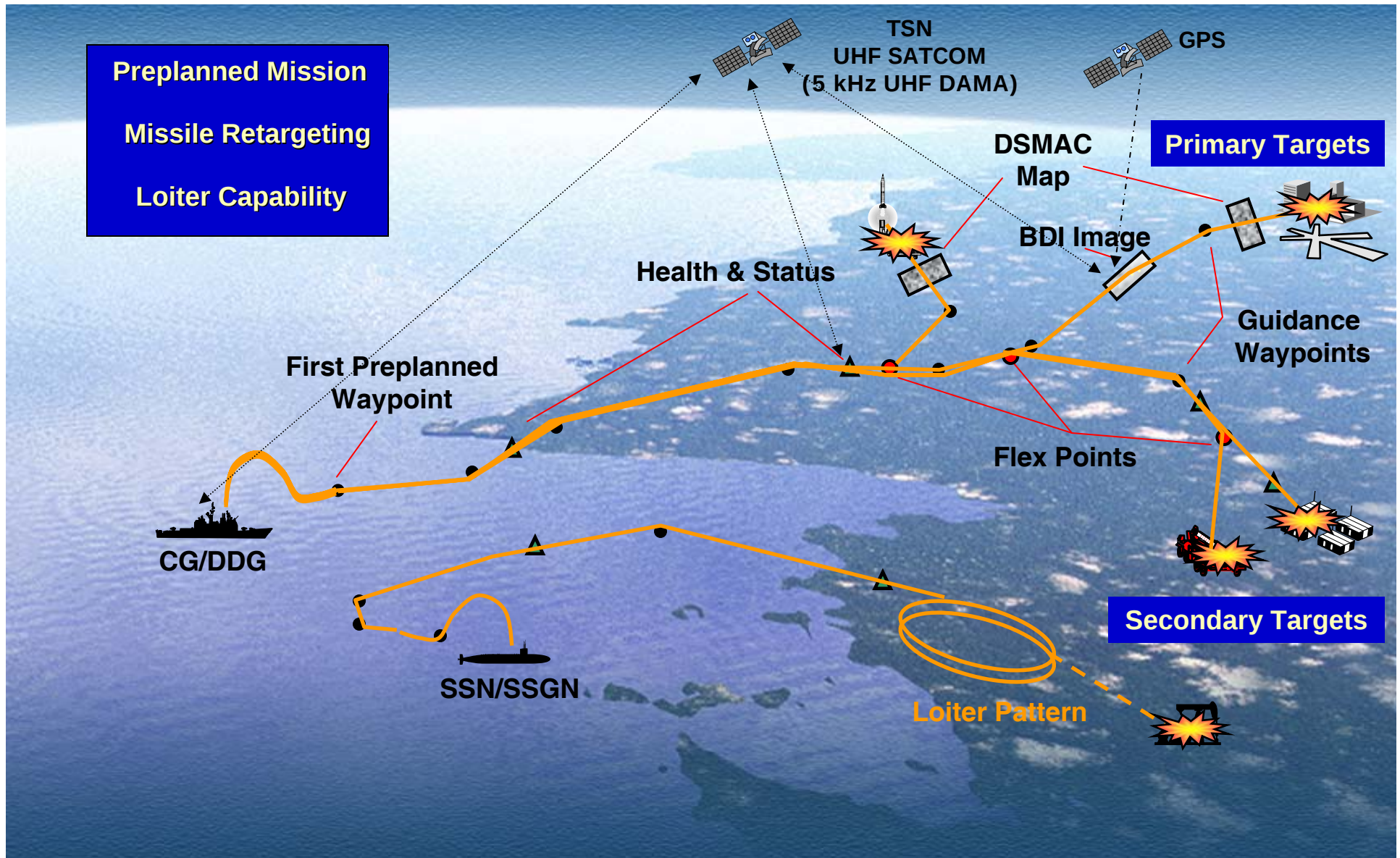
Tomahawk *System of Systems*



Tomahawk Development History

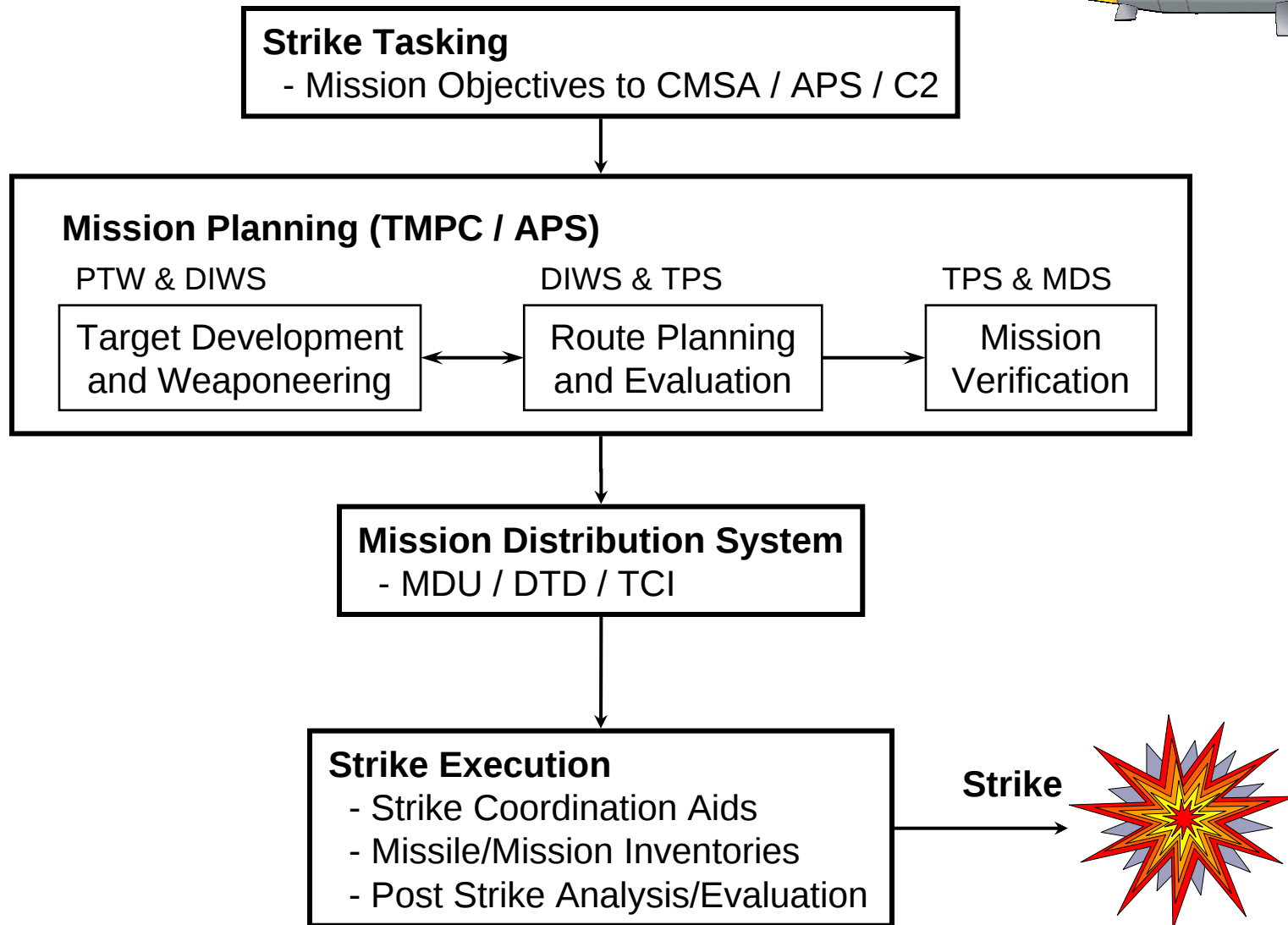
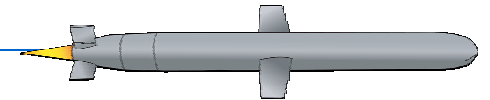


Blk IV Mission Flexibility and Responsiveness



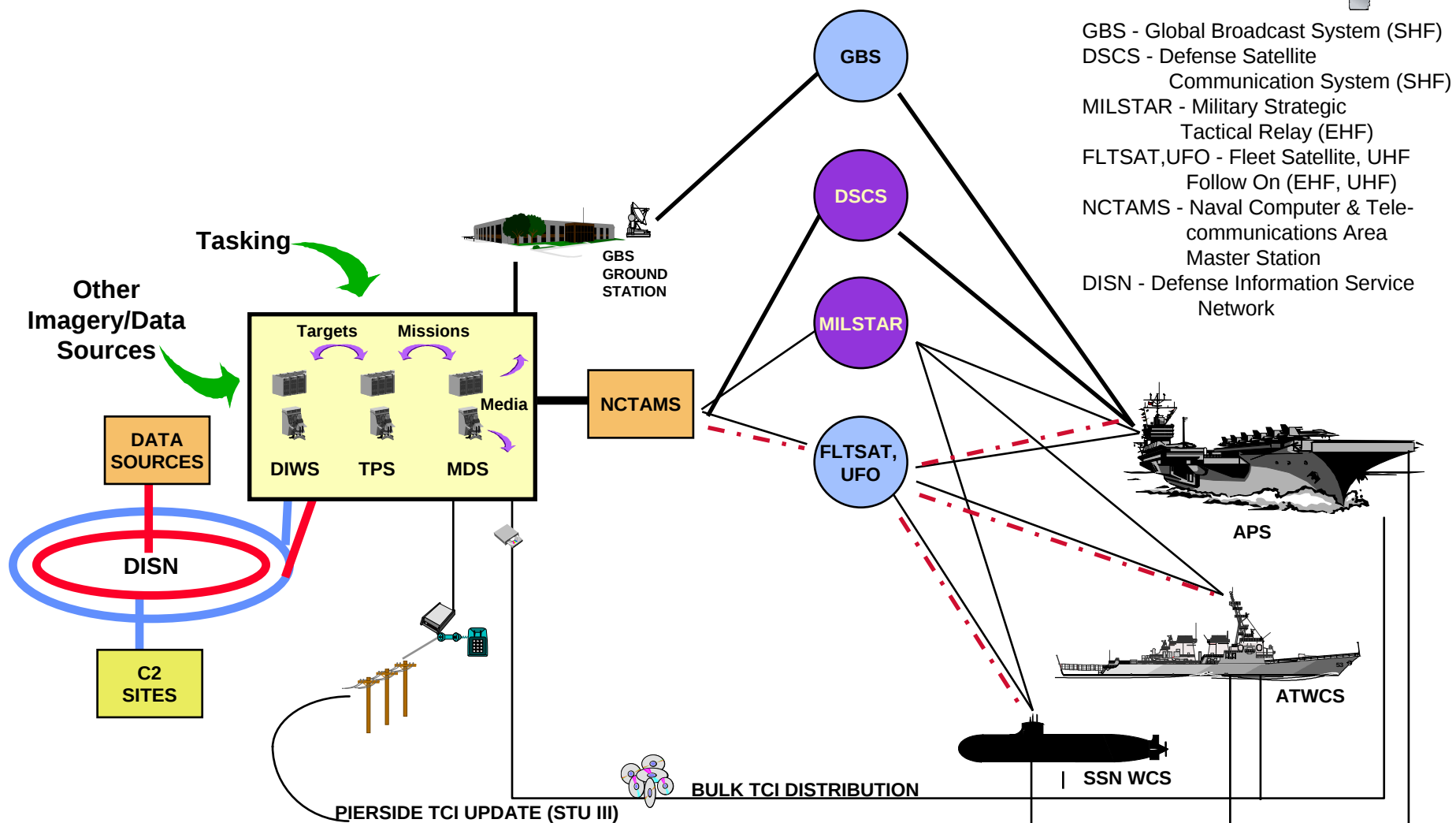
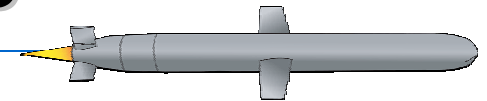


Tomahawk Command and Control System





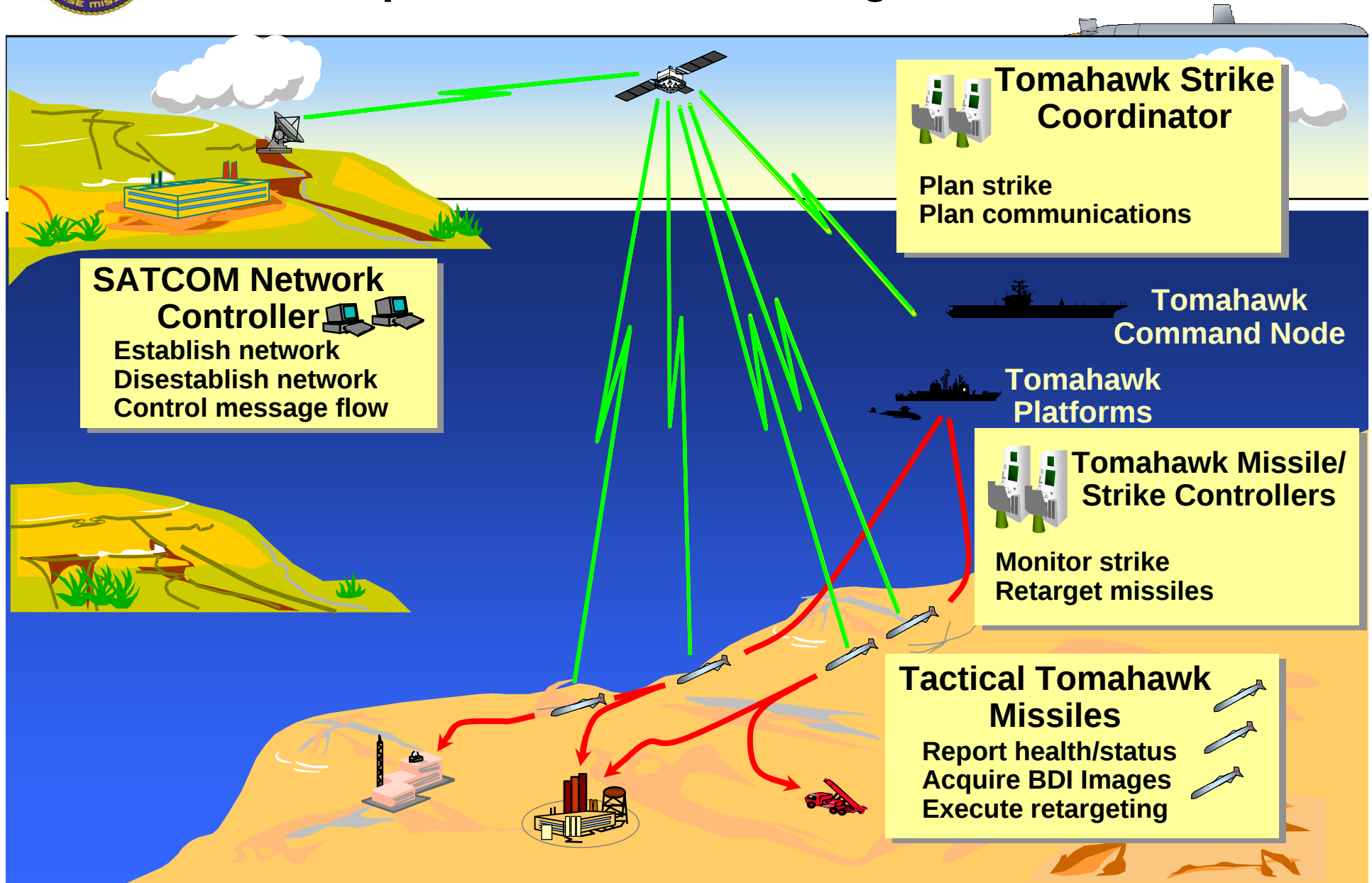
Tomahawk Communication Information Infrastructure





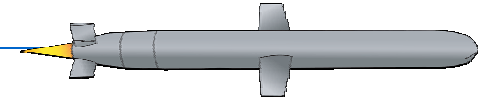
Tomahawk Strike Network

is composed of the following elements:





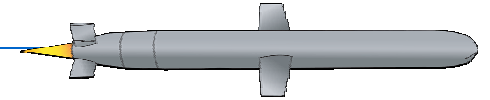
Test Challenges



- 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



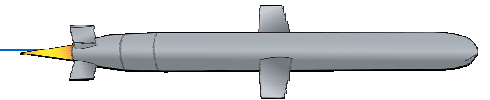
Simulations Used for Test



- Mission Validation System Tomahawk Engineering Simulation / Monte Carlo (MVS TES / MC)
- Mission Validation System / Register Level Simulation (MVS / RLS)
- Tactical Simulation (TACSIM)
- 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 (LASIL)
- Register Level Simulation, Tomahawk Missile in the Loop (RLS / TMIL)



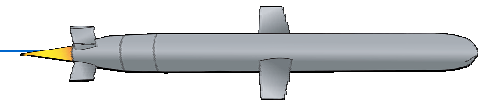
TECHEVAL Test Events



- **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)



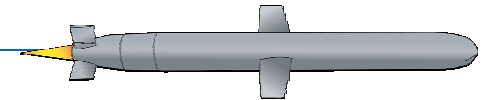
OT Test Configuration



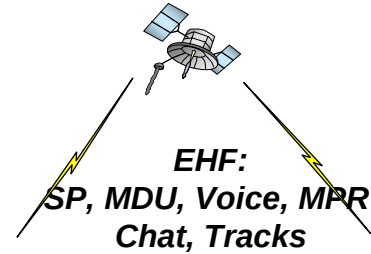
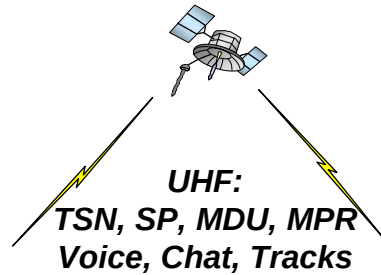
OT Event \ Test Asset	USS STETHEM	USS TUCSON	TTGP	EWTGPAC	STT	NSWC DD	NUWC Npt	ATWCS Ship	AOSDLANT	NSWC Corona	UHF SATCOM	EHF SATCOM	TTMMCS
Event 1: 96 Hour Scenerio	X	X	X	X	X	X	X	X	X	X	X	X	X
Event 2 : Flight Tests	X	X	X								X	X	
Event 3: LASIL						X							
Event 4: Mission Planning & Validation	X	X							X				



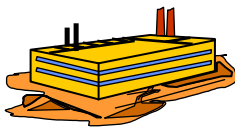
DT-IIC End-to-End @ Sea



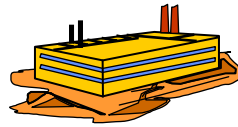
Satellite Comms



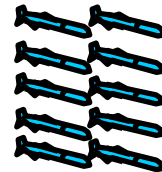
Command and Control



WPC
(TACSIM)



**TSC/SACC/
Strike Controller**
TACTRAGRUPAC



TTMMS-DT
APL



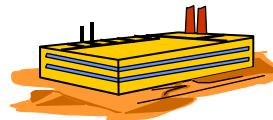
NSWC/IHD
(TAFS/TMIL)

Firing Units

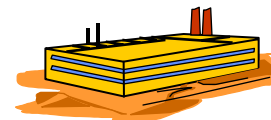
DDG-63



(Tactical Mode +
TMEUs/MK 96s)



NSWC/DD
(TTWCS/ATWCS in tactical mode/
IDSIM)



NUWC/NPT
(TTWCS in tactical mode/
MK 101)

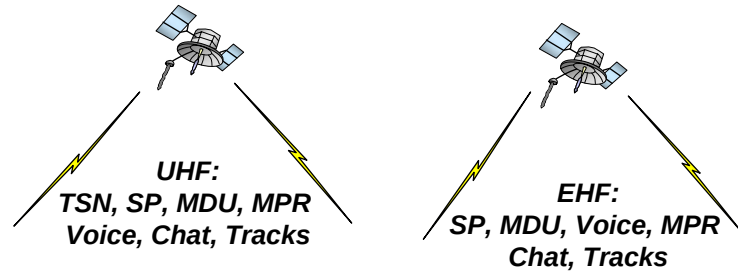
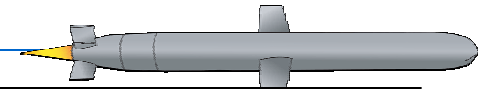
TBD SSN



(Tactical Mode +
Mk 101)



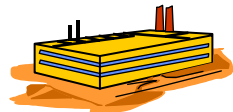
OTDR Test Goals / Participants



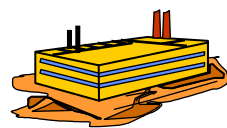
Satellite Comms

Test Goals:

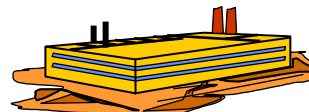
- Comprehensive System End-to-End Test
- Mimic OT 96 HR Scenario
- Demonstrate System Functionality from Mission Planning to Target Engagement
- Exercise External Interfaces in a simulated tactical environment



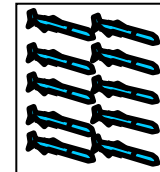
NSWC Corona
(Contact Broadcast)



AOSDLANT / WPC
(Mission Planning)



TSC/LAC/SC (TFCC)
Alt SC, SACC (PCC)



TTMMCS

TACTRAGRUPAC



STT, HI
(Alt SC)

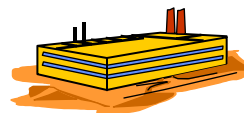
Command and Control

DDG-63
(Missile Controller)

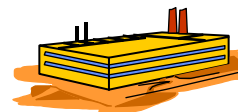


(Tactical Mode +
TMEUs, MK96,
M683s)

Firing Units



USS NSWC
(TTWCS in tactical mode
+ VLSS)



USS NUWC
(TTWCS in tactical mode/
MK 101)

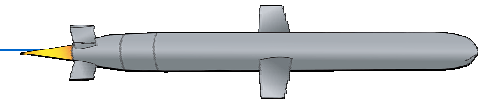
SSN 770
(Missile Controller)



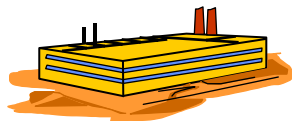
(Tactical Mode
+ Mk 101 Sim)



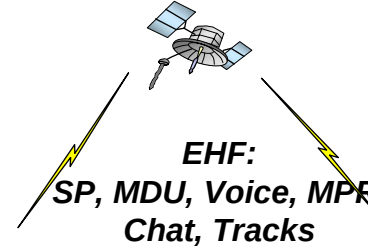
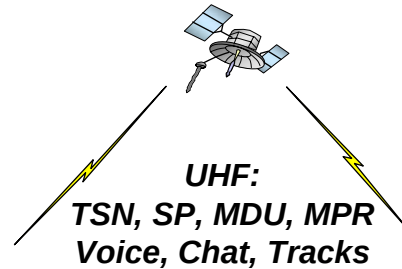
OT-IIC End-to-End @ Sea



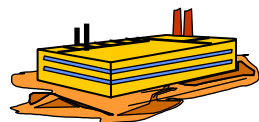
Satellite Comms



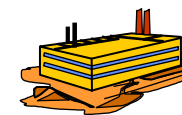
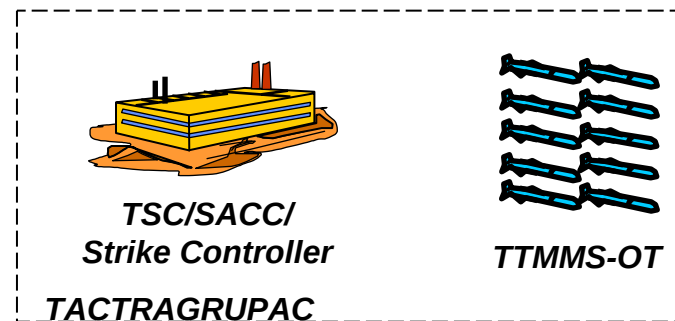
NSWC Corona
(Contact broadcast)



Command and Control



CMSAPAC



STT, HI
(Alt SC)



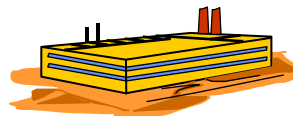
Forward Observers
(Satcom voice)

Firing Units

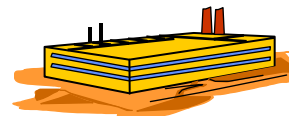
DDG-63



(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)

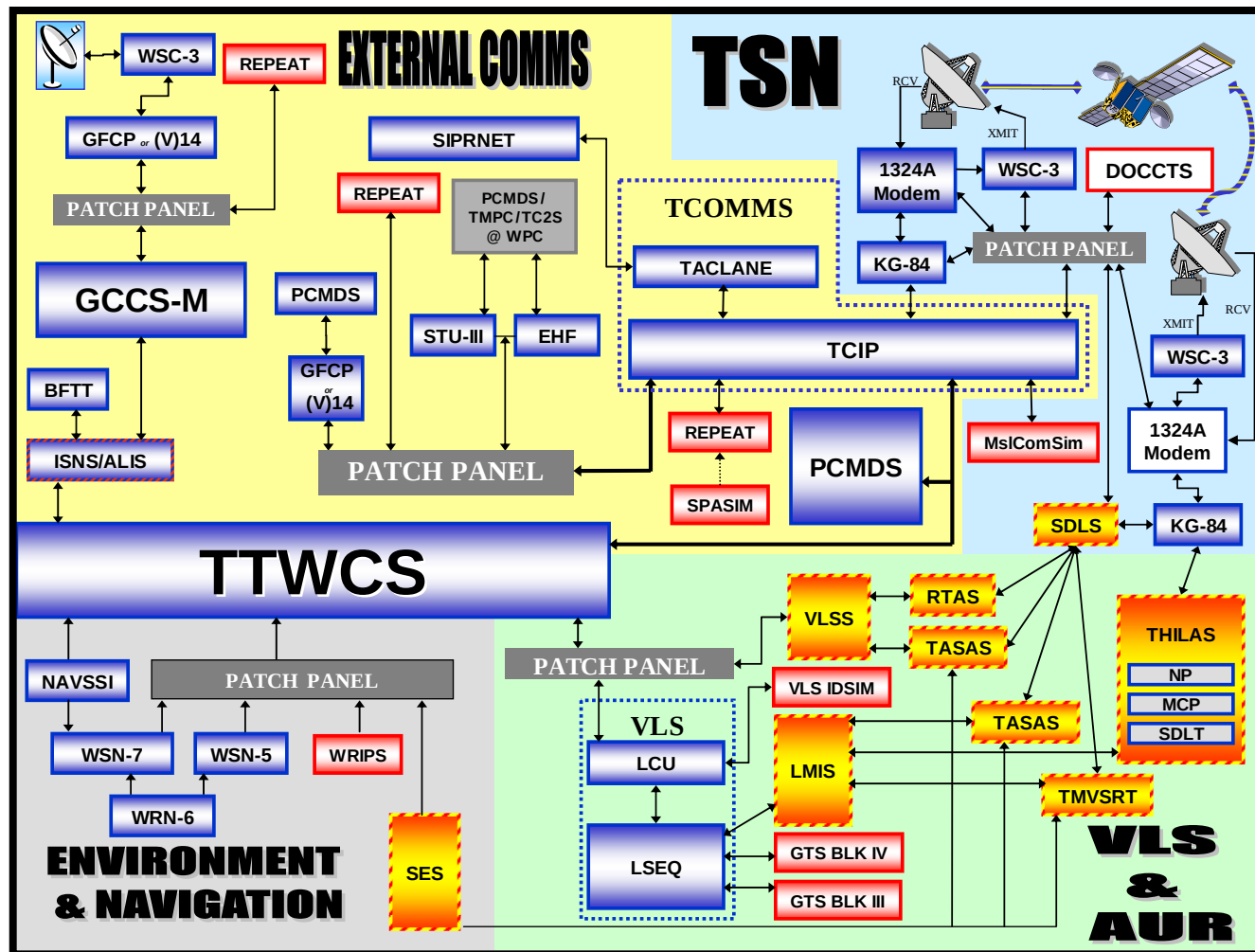
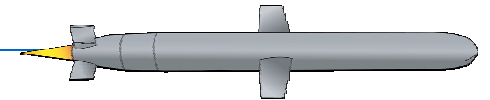
**ATWCS
Shooter**



(Training Mode)



Land Attack Systems Integration Laboratory



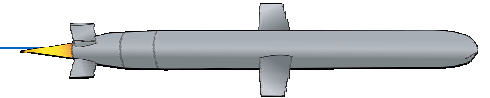
Tactical Equipment

Simulation Equipment

SEMS Equipment



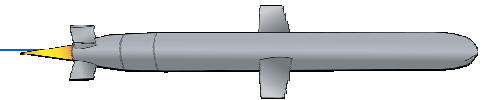
Lessons Learned



- 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

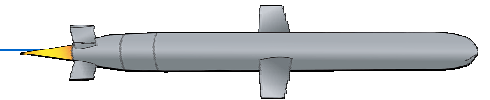


- Tomahawk continues to pioneer the use of M&S in large scale *systems of systems* testing
- VV&A applies to the whole test configuration – not just traditionally defined M&S
 - Test sites
 - Test configurations

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
- MIDB – Modernized Integrated Database
- MILSTAR – Military Strategic Tactical Relay
- NIMA – National Imagery and Mapping Agency
- NCTAMS – Naval Computer & Telecommunications Area Master Station
- OT – Operational Testing
- PCMDS – Personal Computer Mission Distribution System
- PTW – Precision Targeting Workstation
- SWEF – Surface Warfare Engineering Facility
- TCI – Tomahawk Command Information
- TC2S – Tomahawk Command and Control Segment
- TERCOM – Terrain Contour Matching
- TPS – Tomahawk Planning System
- TSN – Tomahawk Strike Network
- TMMCS – Tactical Tomahawk Multi-Missile Communications Simulator
- TTWCS – Tactical Tomahawk Weapons Control System
- WCS – Weapons Control System



Questions?