Expanded Use of the Probability of Raid Annihilation (P_{RA}) Testbed

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PRA 101

- **CNO's Anti-Air Warfare Capstone Requirements Document (1996) mandated the ship self defense capability for specific ship classes and established the Probability of Raid Annihilation (P_{RA}) as the primary Measure of Effectiveness (MOE) to assess ship combat system suites.**

- **P_{RA} is defined as the ability of a particular stand-alone ship, as an integrated system, to detect, control, engage, and defeat a specified raid of ASCM threats with a specified level of probability in the operational environment. The P_{RA} MOE is a system-of-systems measure which is levied on the ship defense suite as a whole to properly detect, control, and engage (annihilate) a raid of incoming threat ASCMs. Thus, it doesn't measure the performance of any particular ship defense element; rather it measures the system performance of all the ship defense elements across the complete battle timeline.**

- **The LPD 17 Class is the first U.S. Naval ship class required to demonstrate its ability to defeat specific anti-ship cruise missile threats to achieve a statistical P_{RA}.**

History

- 2000:

  DOT&E and COTF start to place significant emphasis on P_{RA} . The Navy starts to devise its strategy.

- 2001:

  PEO IWS prototypes and performs an engineering demonstration of a M&S Federated solution, dubbed the P_{RA} Federation Test Bed.

- 2002:

  PMS 317, PEO IWS, N75, N76, DOT&E, ASN(RDA), & DASN Ships decide how to handle combat systems integrated testing, SDTS, and P_{RA}. The federated Testbed approach was selected as the Navy's solution of choice for P_{RA} assessment.

- 2003:

  PMS 317 & PEO IWS form the LPD 17 P_{RA} Team and it is tasked to begin Testbed development.

History cont'd

• Requirements Document	Jan 04
• Build 1	June 05
• Build 2	March 06
• Build 3	June 07
• Build 4/CSSQT Replication	March 08
• DT Runs	March 08-May 09
• DT Report/Start Runs for Score	July 09
• Finish Runs for Score	September 09
• V&V Report	December 09
• COTF Accreditation	April10

Fundamentals

- Bound a problem with infinite possibilities.
- Make it reasonable and within a reasonable **operational** context.
- Not skewed in any one point of view.
- Scientifically supported; no need wasting money on physics not understood.
- Consistent across ship classes.
- ‘High’ Fidelity Models

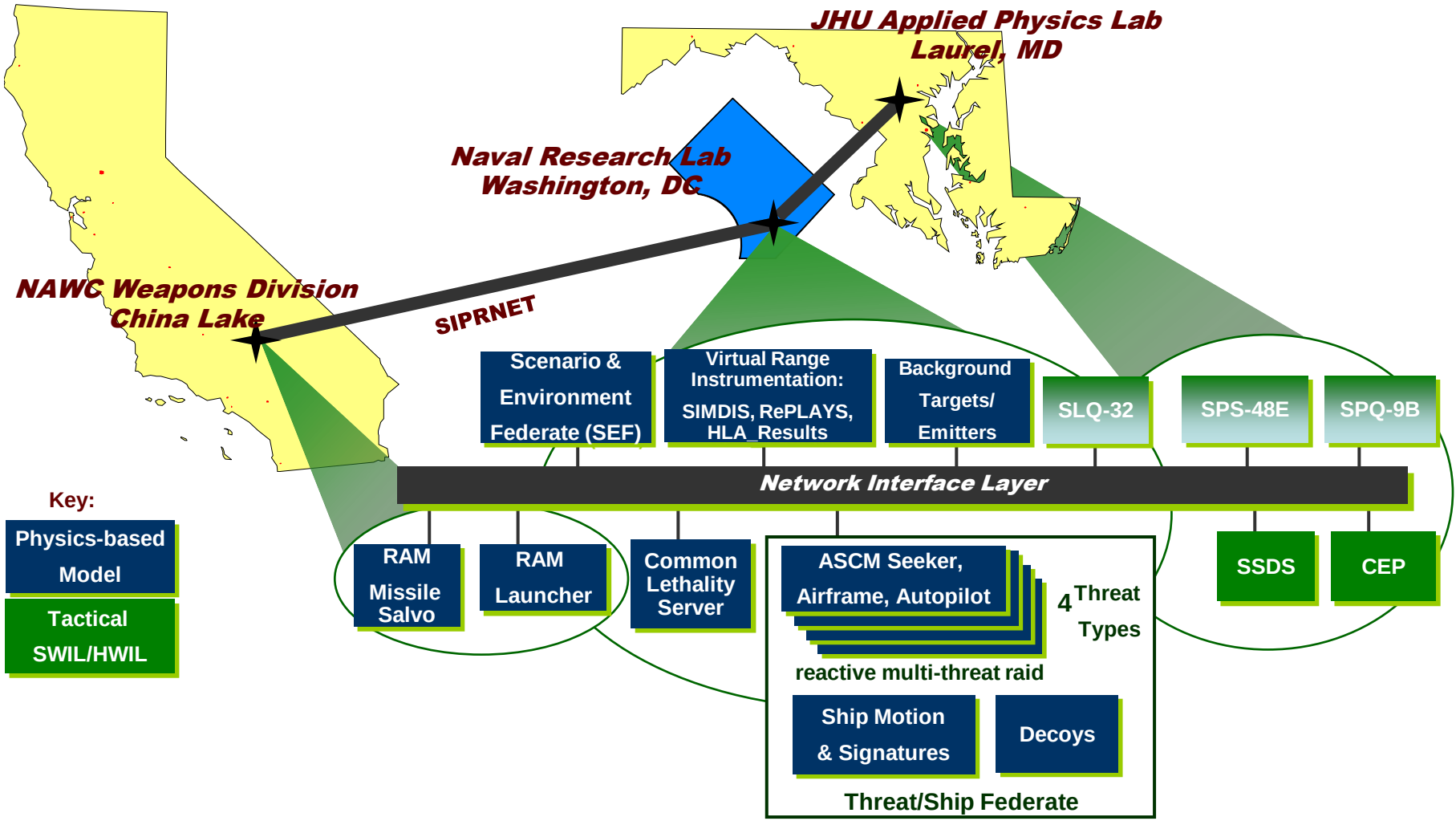
PRA Threat Descriptions

- T1 --Seaskimming, subsonic, RF, non-maneuvering
- T2 --Seaskimming, subsonic, IR, non-maneuvering
- T3 --Not available for P_{RA} (Supersonic, RF, Maneuvering)
- T5 –Updated tactic narrows scope of analysis for execution (High Diving, supersonic, ARM)
- T7 --Seaskimming, supersonic, advanced RF

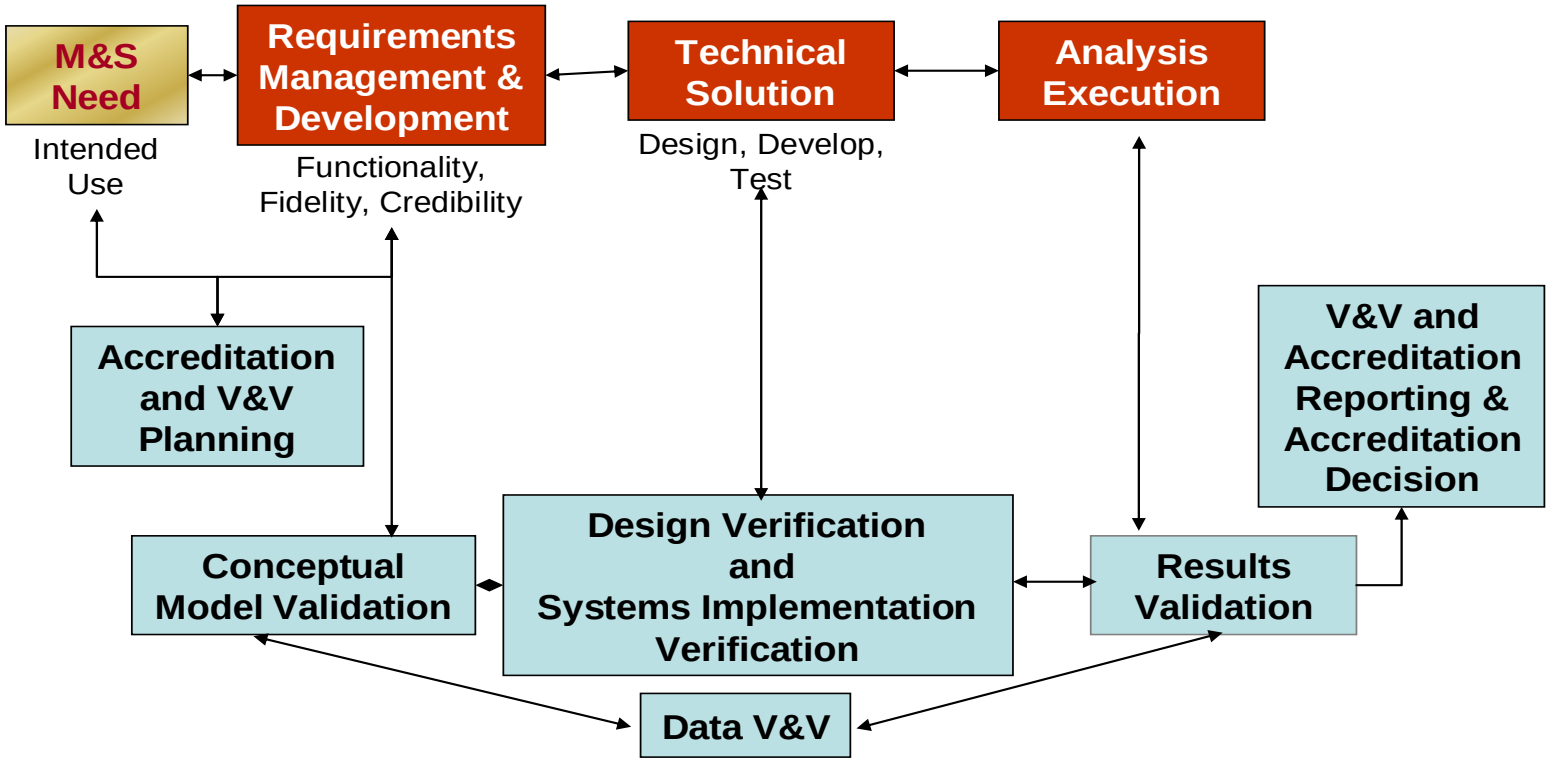
Analysis Approach Overview

- 2 Geographies
  - Mid Med Open Ocean
  - Straits of Hormuz
  - Provides stressing and non-stressing locations
- 2 Environments
  - 2 times of year
  - 5 times of day
  - No rain
  - Provides nominal changes in environment
- 2 Radar Cross Sections
  - Clean, fully buttoned up
  - Dirty, open well, helos on deck
  - Provides “easy to see” and “not so easy to see” signatures
- 4 Threats
  - T1R1, T2, T5, T7
  - 8 threat bearings
  - 45 deg interval
  - Provides stressing and non-stressing threat bearings

Testbed Description



M&S and VV&A Processes



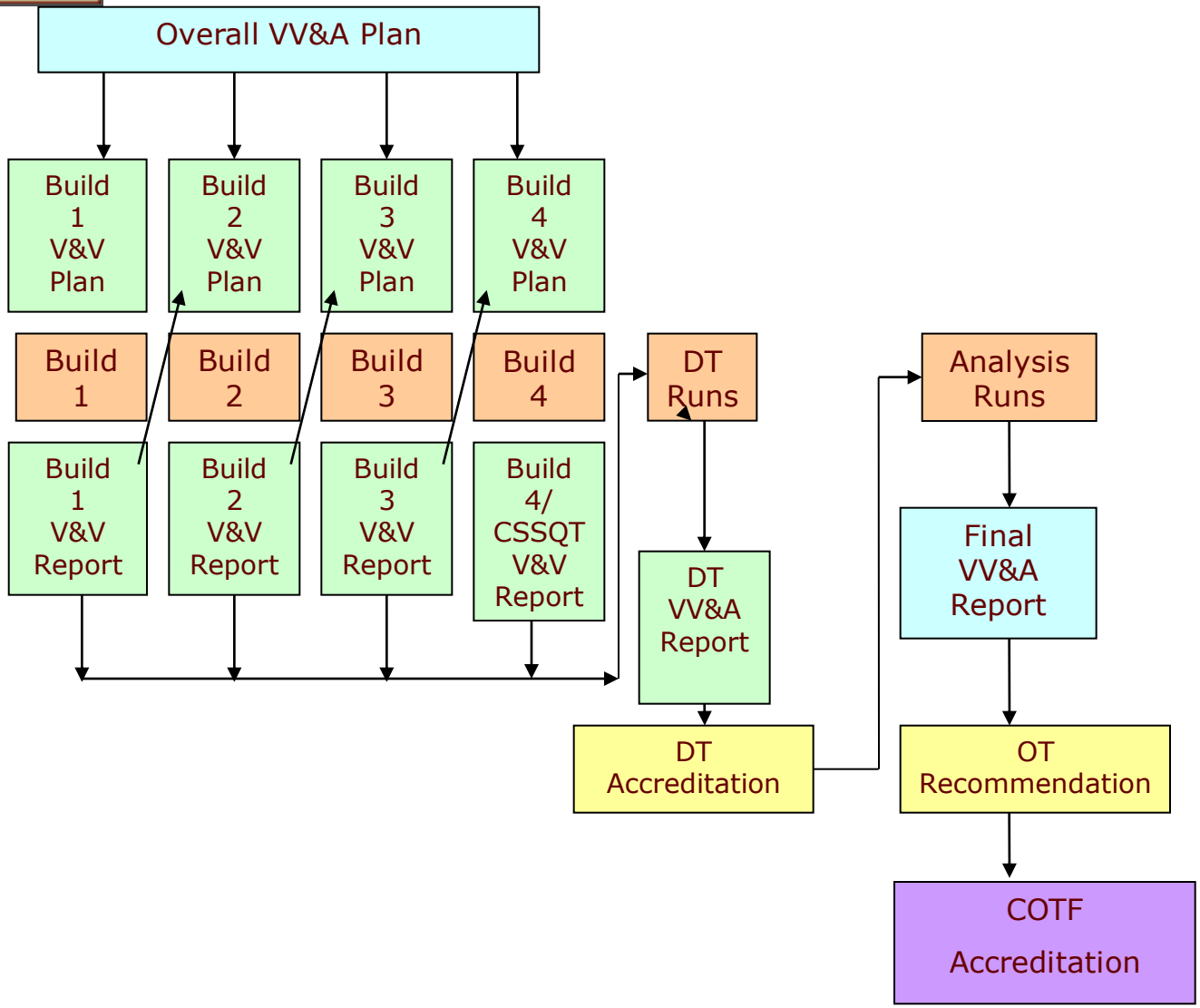
V&V/Design Philosophy

- LPD 17 Top Priorities
- Maximize use of rehosted tactical code
  - Permits communication between elements as they were designed.
- Reuse established/available models
- Obtain actual environmental data from authoritative sources
- Requirements Based
- Requirements Traceability
- 4 Steps of V&V
  - Conceptual Model Validation
  - Design Verification & Systems Implementation
  - Data V&V
  - Results Validation
- V&V Database Tool

Testbed V&V Approach

- Decompose Testbed Requirements to Element Requirements
- V&V of Testbed is Complete When:
  - Element Requirements are V&Ved
  - Testbed Requirements are V&Ved
- Replication of LPD 17 Live Testing and CSSQT Events

VV&A Documentation

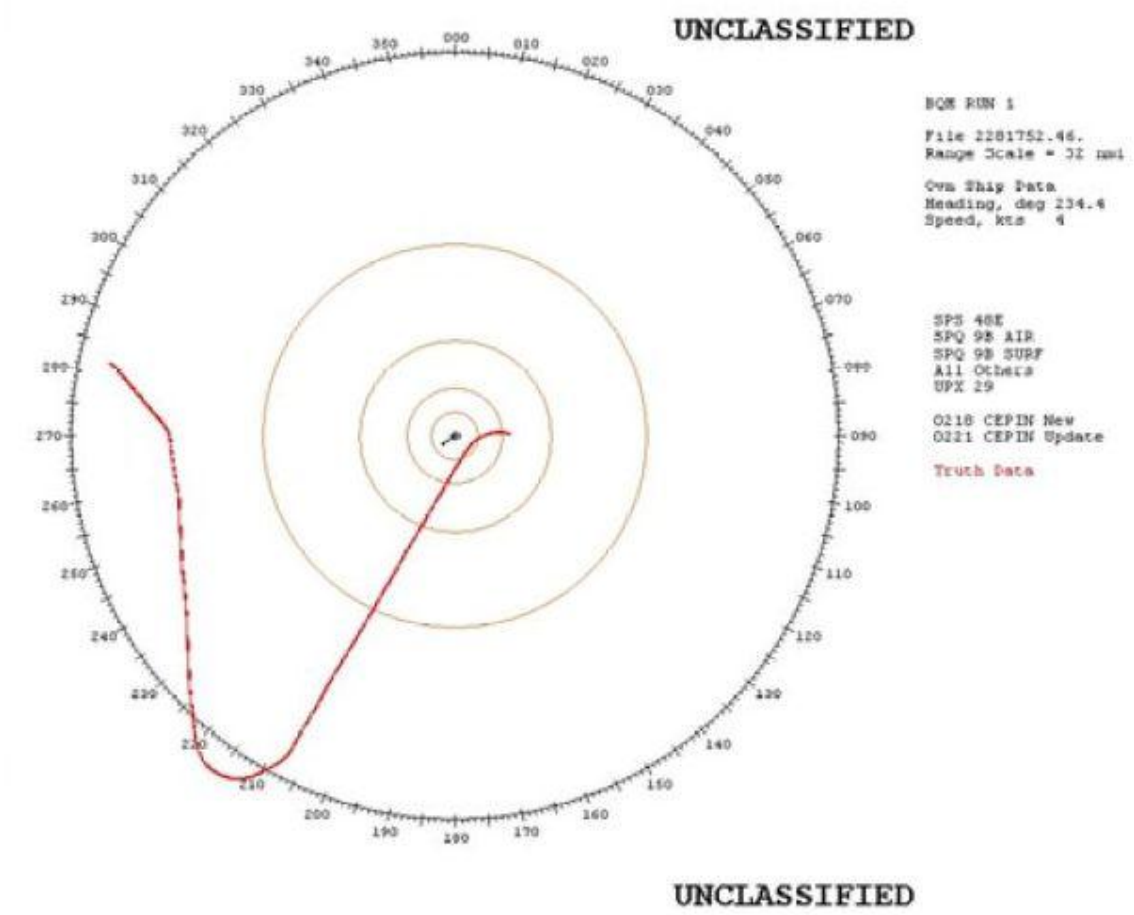


LPD 17 CSSQT

During the LPD 17 CSSQT at Wallops Island Range on 16 Aug 2006, a single IR augmented, I-band TSS equipped, GPS and altimeter tracked BQM-34S flew two separate profiles at the ship for two engagements (MSLEXs) starting at approximately 20 miles from the ship flying at a planned altitude of 50 feet at 450 kn. The environment and inbound target trajectories were reproduced in the Testbed. A Block 0 RAM was fired for the first engagement with SSDS Doctrine in 'Semi-Auto'. A RAM fired from the forward launcher initially guided on the target, but failed in flight. This event was replicated in the Testbed with SSDS in 'Auto', and a RAM flight was not simulated. For the second MSLEX, SSDS was in 'Auto', the emitter on the target was turned off, and the RAM fired from the aft launcher missed the target because of a pointing error. When replicated in the Testbed, this RAM missed as well.

The LPD 18 CSSQT used the upgraded SSDS version which resulted in a skin-to-skin hit against the target

CSSQT Trajectory



Replication Approach

- The Testbed executed two replication runs for CSSQT MSLEX 1, and two replication runs for CSSQT MSLEX 2.
- The Testbed executed single runs for each of the CSSQT MSLEXs with the upgraded version of SSDS (5.04.07)

Limitations to CSSQT Runs

- Limitations do not effect outcome:
  - SSDS doctrine: ‘Auto’ only
  - No SLQ-32 operators in Testbed
  - No background tracks in Testbed (Effects RAM mode, (AIR/DME) vice AIR) but not trajectory)
  - Only core ID doctrine in CEC. IFF not modeled
  - Target trajectory replicated from IP inbound
  - Ability to correlate other radar detections not cost effective

Limitations to CSSQT Runs (cont'd)

- Limitations do not effect outcome:
  - RCS of modeled target smaller than actual BQM
  - Environment measured along firing radial used for 360° representation
  - AEM/S did not affect actual event/not modeled
  - CRS substituted for 2nd RAM in actual event
  - Block 0 RAM not available for model
  - No contribution from Surface Search radar in Testbed

Comparative Analysis Approach

- Comparative Analysis of:
  - Ship vs Testbed DTE Timeline (Key Events)
  - Level 2 and 3 Analysis
    - BQM Ground Truth to Testbed BQM Ground Truth
    - Ship vs. Testbed sensor positional time history
    - RAM post flight analysis
- Testbed Ground Truth Replicates Live CSSQT Ground Truth well (within ~ 2 m at 0.1 sec granularity)
- SPS-48E and SPQ-9B, SLQ-32, and RAM performance comparable to actual CSSQT Event
- DTE timelines comparable to actual CSSQT Event

Key Events

- Threat appears in the scenario
- SPS-48E initial radar detection of the threat(s) (time, bearing, range)
- SPQ-9B initial radar detection of the threat(time, bearing, range)
- SPQ-9B Commanded High Data Rate
- SLQ-32 EPN (14 = New Emitter)
- CEC formation of composite track (track TSPI) (time, bearing, range)
- SSDS EFX assignment to SLQ-32 track number
- SSDS Prompt for DDI engagement
- NULKA Launch
- SLQ-32 Detection (time, parameters, bearing)
- SLQ-32 Detection (time, parameters, bearing)
- SSDS Power Adequate (time)
- Original SSDS RAM Order for Engagement (threat, emitter high/low, AIR/DME)
- Final SSDS RAM Order for Engagement (threat, emitter high/low, AIR/DME)
- RAM Launcher Brg/El at RAM launch(time)
- RAM Missile Fired (missile number, RAM target number, mode)
- RAM Missile Modes
- Detonation (result)
- DDI Auto engagement
- IR Decoy Launch
- Chaff Decoy Launch
- EW Supervisor Engagement Request

T&E Enterprise

- Same approach as LPD 17, but different.
- LHA 6 currently being integrated
- Requirements changes
- Non-Determinism
- Design of Experiment
- Future uses of the Testbed being considered beyond P_{RA} analysis.
  - Preflight Prediction, Trade Studies, Tactics, Training

Surface Ship Test & Evaluation Enterprise Probability of Raid Annihilation (PRA) Analysis Testbed

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