



# **Modeling and Simulation of System of Systems The History of the LPD 17 PRA Testbed**

**M&S Studies in the Context of T&E and Acquisition  
LPD 17 PRA Testbed  
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# OVERVIEW

- **LPD 17 San Antonio Ship Class**
- **LPD 17 Probability of Raid Annihilation ( $P_{RA}$ )  
Testbed Description and Architecture**
- **Testbed Development Organization**
- **Testbed Documents**
- **Testbed Requirements**
- **Testbed Development Process**
- **Testbed Spiral Development and Schedule**
- **Testbed Analysis and Scenario Development**

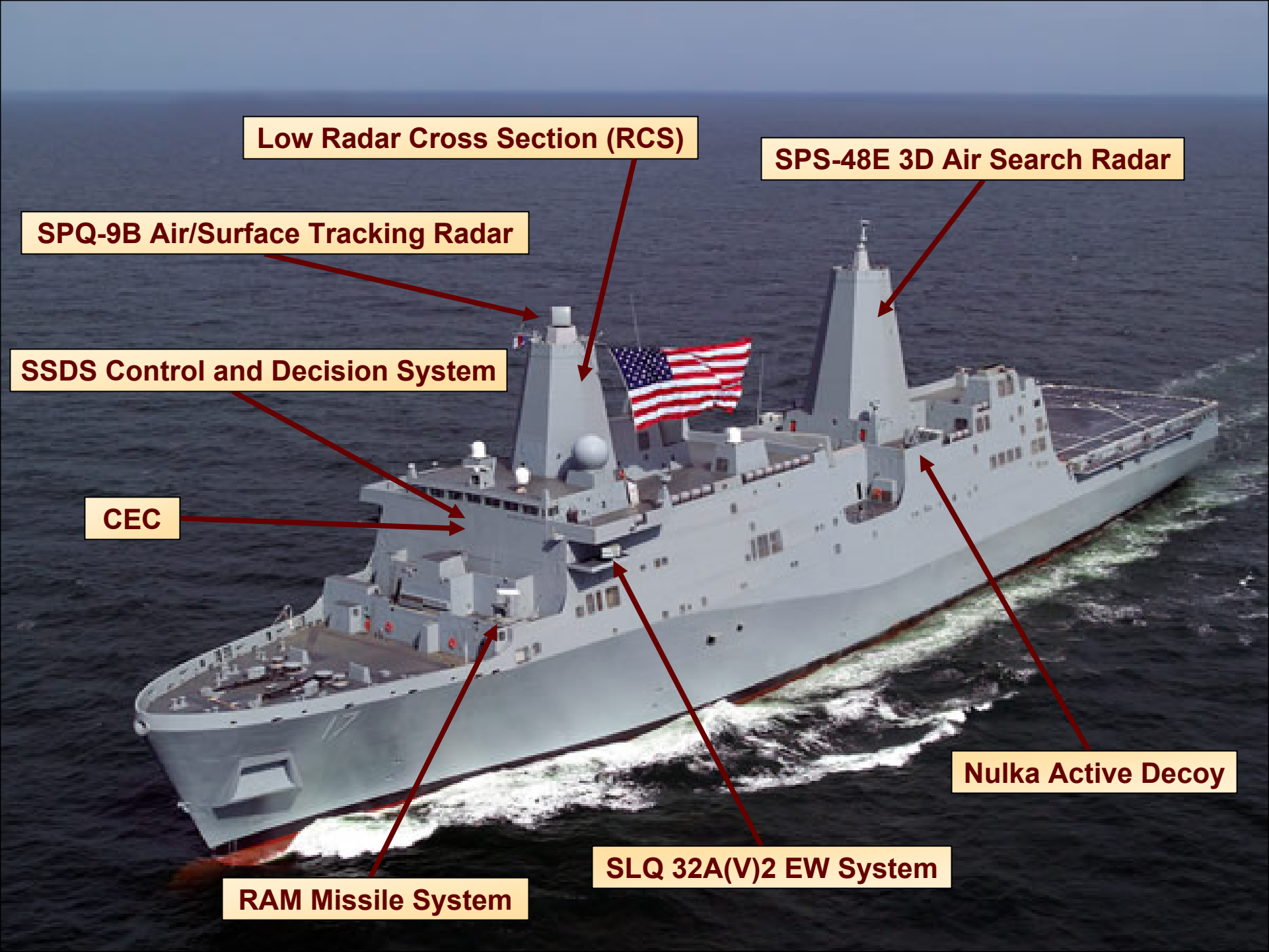




# LPD 17 CAPABILITIES

- **The LPD 17 capabilities include:**
  - State-of-the-art command and control suite
  - Advanced ship survivability features that enhance its ability to operate in the unforgiving littoral environment (low radar cross section)
  - Substantially increased landing force vehicle lift capacity (23,600 square feet of vehicle storage space),
  - Large flight deck (land 2 MV-22 or 4 CH-46) and well deck (holds 2 Landing Craft Air Cushion {LCAC})
- **The LPD 17 is the first amphibious ship designed to accommodate the Marine Corps' "mobility triad"**
  - Expeditionary Fighting Vehicle (EFV)
  - LCAC
  - MV-22 Osprey tilt rotor aircraft.

**OUR FOCUS WILL BE ON THE COMBAT SYSTEM**



**Low Radar Cross Section (RCS)**

**SPS-48E 3D Air Search Radar**

**SPQ-9B Air/Surface Tracking Radar**

**SSDS Control and Decision System**

**CEC**

**Nulka Active Decoy**

**RAM Missile System**

**SLQ 32A(V)2 EW System**



# BACKGROUND – P<sub>RA</sub>

## OBJECTIVE: ASSESS LPD 17's P<sub>RA</sub> (ABILITY TO DEFEND ITSELF AGAINST INCOMING MISSILES)

- CNO's Anti-Air Warfare Capstone Requirements Document mandated the ship self defense capability for specific ship classes and established the Probability of Raid Annihilation (P<sub>RA</sub>) as the primary Measure of Effectiveness (MOE) to assess ship combat system suites.
- P<sub>RA</sub> 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 anti-ship cruise missile (ASCM) threats with a specified level of probability in the operational environment.
- The P<sub>RA</sub> 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<sub>RA</sub>.



# NAVY'S SOLUTION TO P<sub>RA</sub>

- **P<sub>RA</sub> Assessment is a Three Pronged Approach**

- **Test against actual ship (LPD 17)**

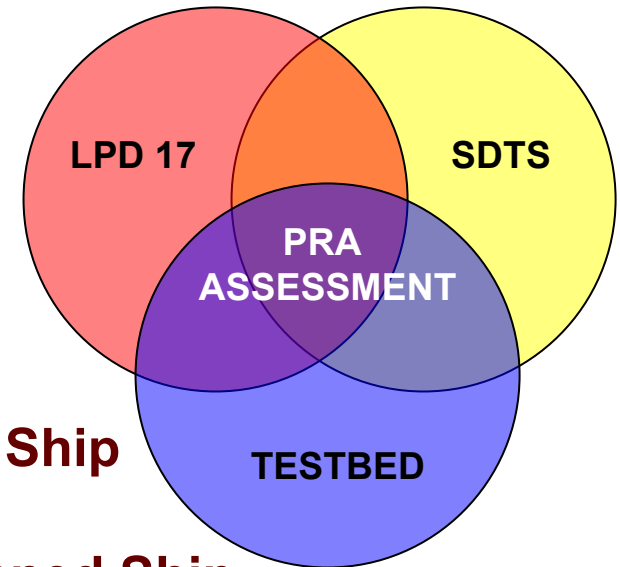
- Pro – Test Drones Against the Actual Ship
- Con – Limited Firing Events, Cannot Fire ASCM Against Manned Ship

- **Test against Self Defense Test Ship (SDTS)**

- Pro – Can Fire ASCM Against SDTS
- Con – Limited Representation of the Actual Ship, Limited Firing Events

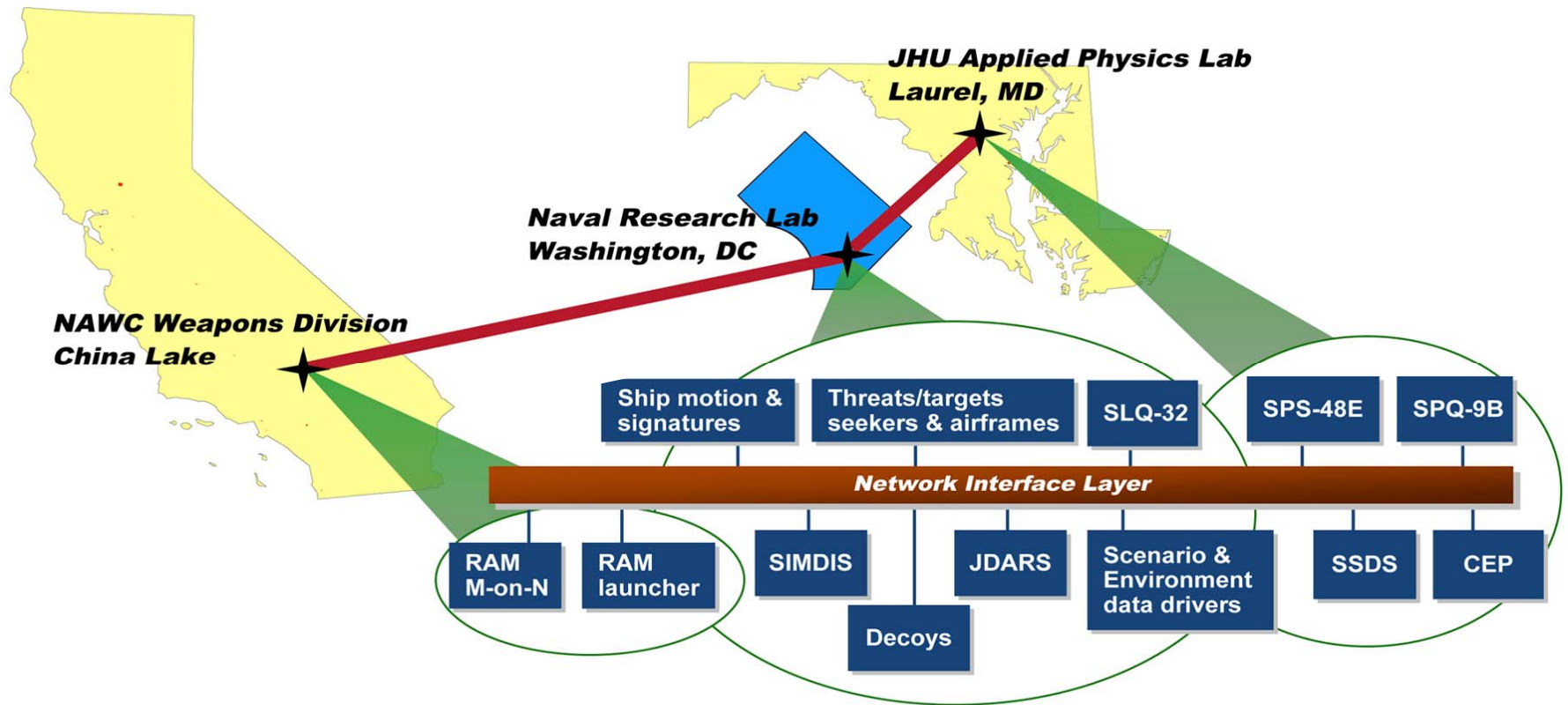
- **Test using M&S (LPD 17 Testbed)**

- Pro – Can Run Numerous Different Scenarios, Events
- Con – Developmental Cost, Limiting Assumptions





# LPD 17 PRA TESTBED



Geographically Distributed Federation of Tactical HWIL,  
Tactical SWIL and Digital Physics Based Models



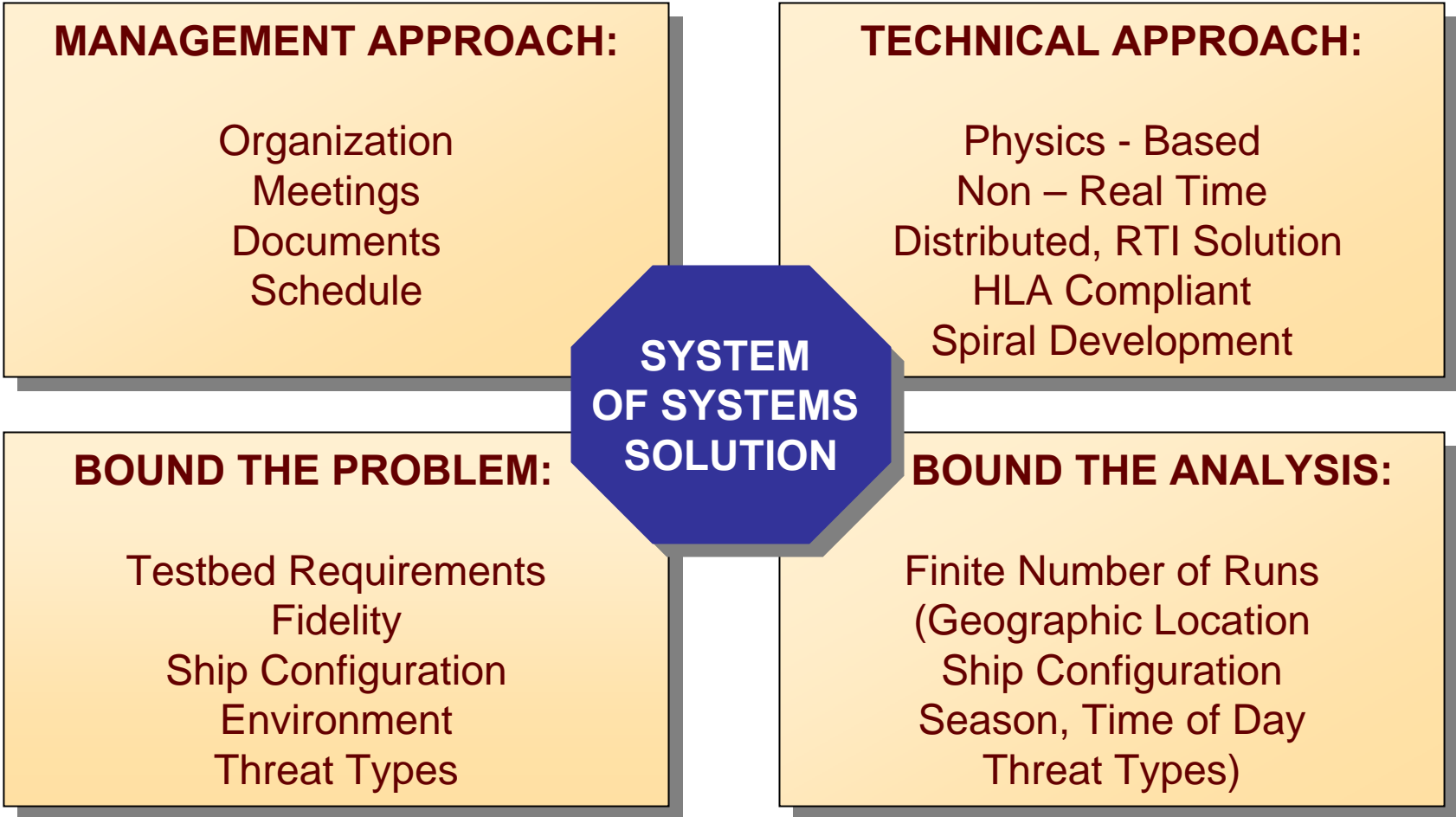


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# LPD 17 P<sub>RA</sub> TESTBED OVERVIEW





# ROLES & RESPONSIBILITIES

- **PMS 317**
  - Manages Funding
  - Drives Schedule
  - V&V Manager
  - DT Accrediting Authority
- **PEO IWS CSE**
  - Manages Testbed Design and Development
- **NRL**
  - Testbed Integrator
- **NSWC Corona**
  - Test Resource, Planning and Data Collection Agent
- **Element PMs**
  - Co-Chair SCP.
  - Review & Approve SOWs associated with M&S Development.
  - Manage/ Participate in Model Development.
  - Responsible for the Credibility of their Respective Models
- **Model Developers**
  - Develops/ Integrates Models
- **COMOPTEVFOR**
  - Participates as the OT Accrediting Authority

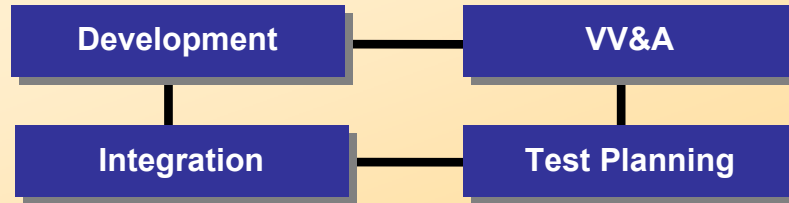


# LPD 17 P<sub>RA</sub> ORGANIZATION

## MANAGEMENT IPT

- LPD 17 Combat System Integration Manager
- LPD 17 Test Director
- Ship Self Defense Combat Systems Engineer
- Deputy SSD CSE

## WORKING IPT



## SIMULATION CONTROL PANELS (SCP)



CS Element PMs



M&S Developers





# TESTBED MEETINGS

**SCP MEMBERS,  
DEVELOPERS,  
EXPERTS**

**WORKING  
IPT  
MEMBERS**

**MANAGEMENT  
IPT  
MEMBERS**

**Semi-Annual Reviews**

**Testbed Demonstrations**

**Monthly Testbed Meetings**

**Periodic Meetings – Specific Issues**

**Federation Object Model Meetings**

**Phenomena Meetings**



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# TESTBED DOCUMENTS

## REQUIREMENTS DOCUMENT

Testbed and Model Requirements

Defined at the Beginning

## TESTBED AND MODEL BUILD PLAN & REPORT

Technical Approach

Functionality Per Build

Configuration Management

Integration Plan and Report

## SECM

System Engineering

Conceptual Model

Illustrates Model Relationships  
(Links to Supporting Documents)

## VERIFICATION & VALIDATION PLAN AND REPORT

Derived from the Requirements

Generated from

Relational Database

AVW Process developed the Approach, Requirements and Build Plan  
AVW Database Produced the Requirements and VV&A Documents





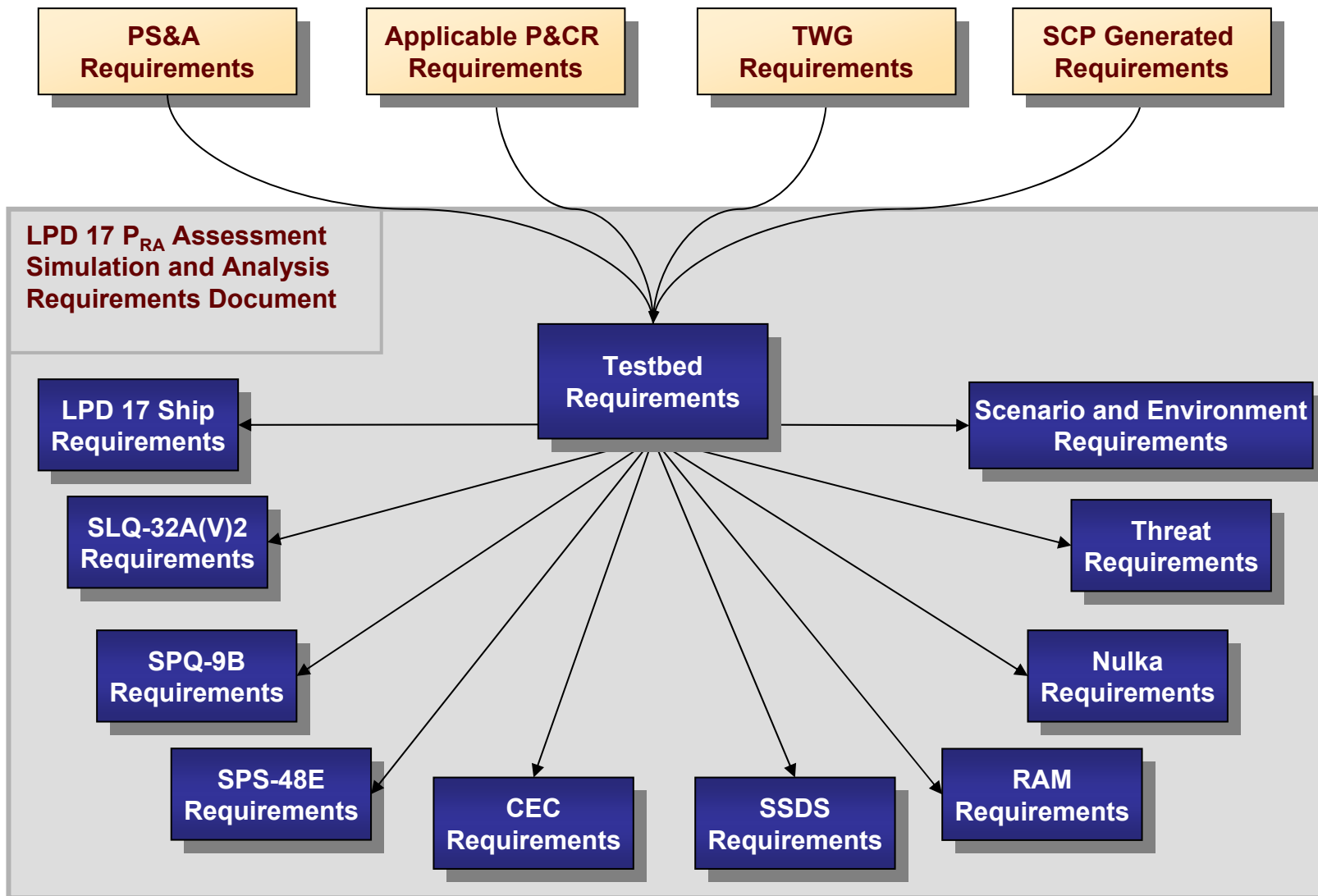


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# TESTBED REQUIREMENTS FLOW



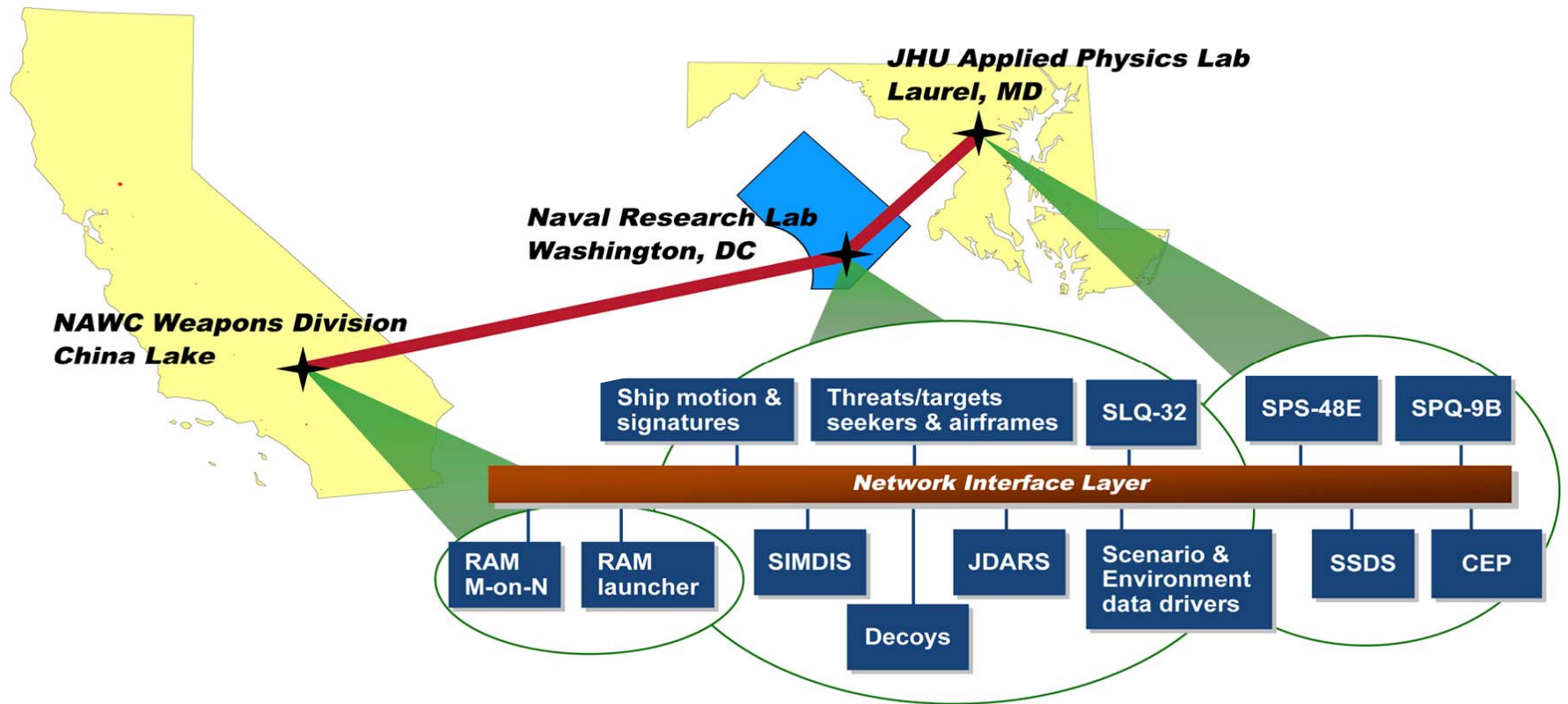


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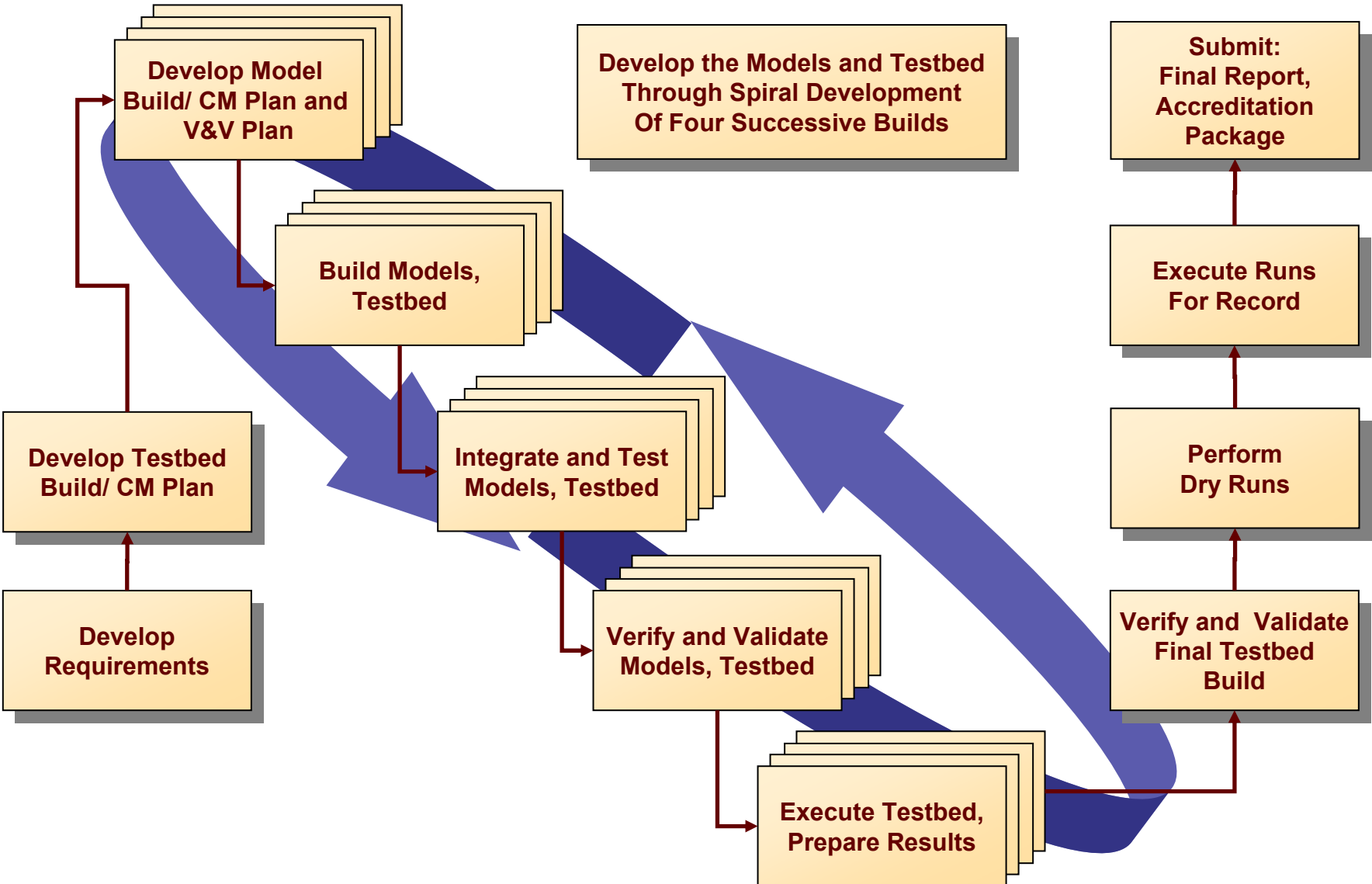
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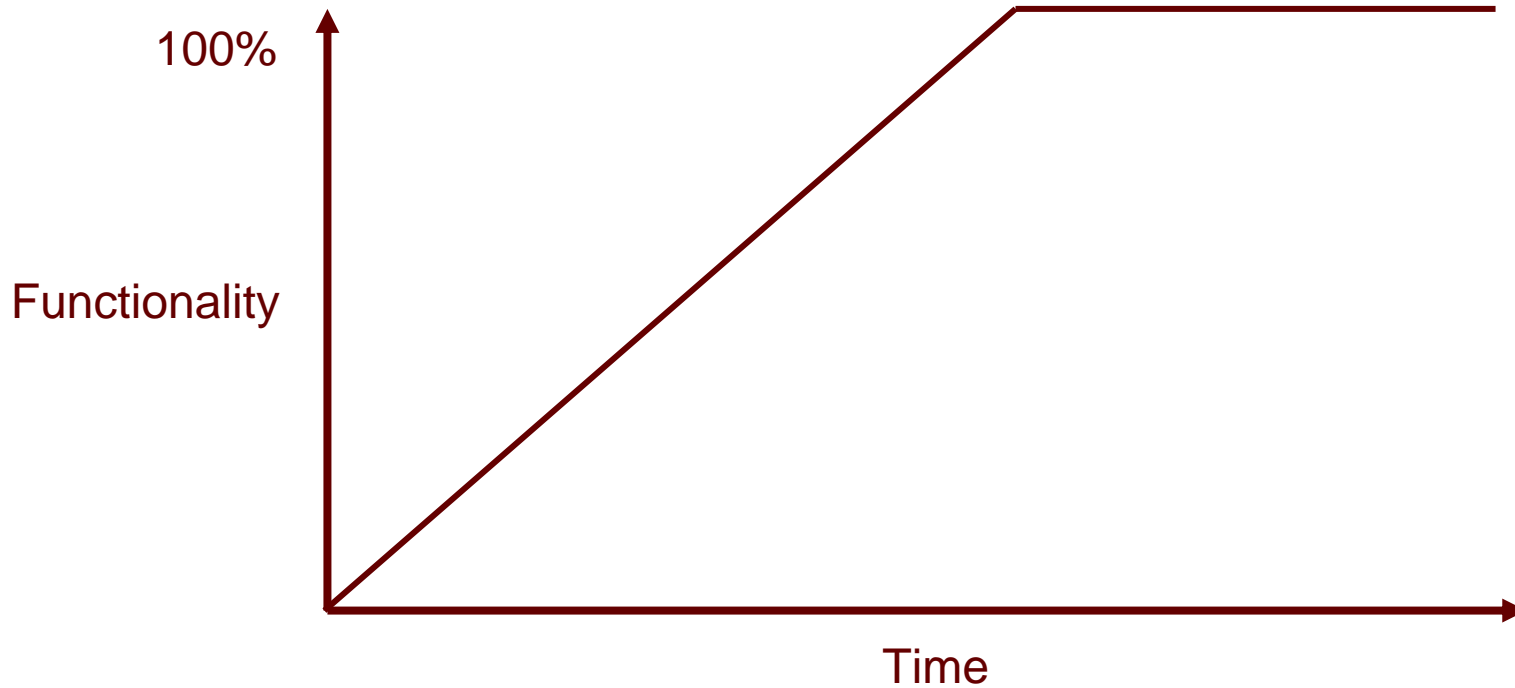


# TESTBED SPIRAL DEVELOPMENT





# DEVELOPMENT TIMELINE





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# ANALYSIS OVERVIEW

- **Objective – to bound a problem having infinite possibilities.**
- **Number of variables limited by time to perform analysis runs**
- **Make analysis space finite and within a reasonable operational context.**
- **Not skewed in any one point of view.**
- **Scientifically supported; no need spending money on physics excursions.**
- **Approach should be consistent across ship classes.**
- **The scenarios are scripted to prevent other ships, LCACs, and aircraft from interfering with the engagement sequence.**
- **The threat should not be distracted from its target by these other units in the scenario.**





# SCENARIO OVERVIEW

- **Background**
  - LPD 17 is part of an Expeditionary Strike Group (ESG).
  - Early detection and engagement of the launching platform is not in the context of the PRA Assessment since its focus is ASCM self defense.
  - Battle force networking, force link tracking and force cooperative engagements standpoint are not supported by the LPD 17 PRA self defense context; therefore, the ship will be in a worst case situation with no data links active, requiring it to perform the entire detect-to-engage sequence on its own.
- **Initial Conditions**
  - Detailed geometries, tactics, and operational situations will be developed to provide boundary/initial conditions for each run as well as to drive the variables during the run to ensure operationally realistic and consistent runs for analysis.



# SCENARIO - THREATS

- **Combat System Setup**
  - Conducting wartime transit steaming and mission operations with the ship's defensive systems set up to counter ASCM threats automatically.
  - No operator actions required except for NULKA launches, which will be treated as a time delay in the automatic engagement sequence based on nominal operator reaction times.
  - Surface Warfare Development Group (SWDG) Tactical Memorandums (TACMEMOs) and other tactics and doctrine publications will be used to configure the LPD 17 Combat System representation in the Testbed for execution of each simulated engagement run.
- **Threats**
  - Threats will be fired in stream raids of x sec spacing, from eight true bearings ( $\pm 8^\circ$ ) about the compass rose.
  - Intelligence on threats and threat tactics will be used to develop detailed threat engagement scenarios for each run.
  - A set of 5 representative threats were selected.



# SCENARIO – SHIP CONFIG

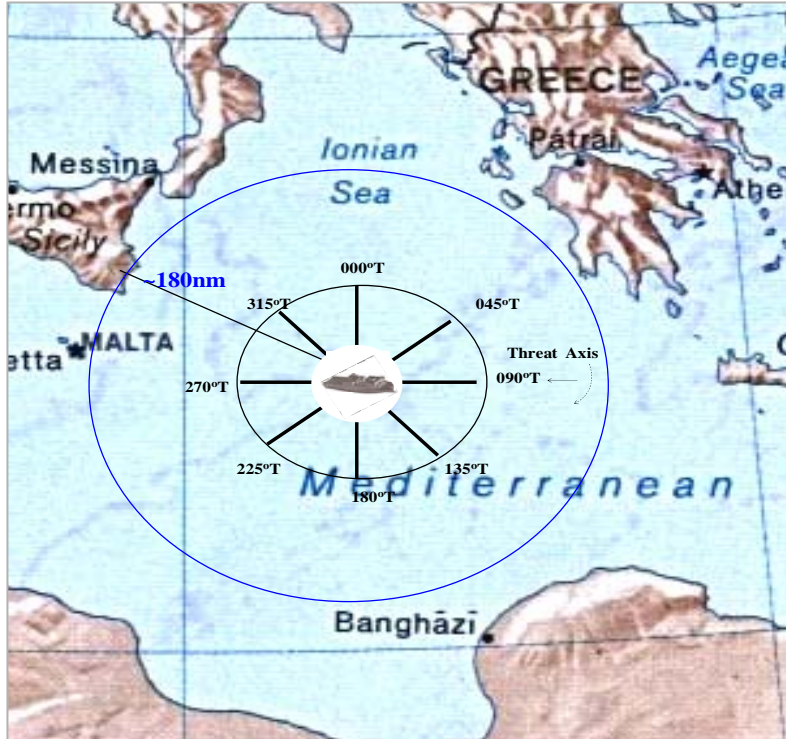
- **Case 1 – “Clean” RCS**
  - The lowest possible realistic RCS and IR values representative of the ship in transit condition in wartime.
  - The flight deck will be as free of aircraft and yellow gear as possible.
  - The stern gate will be closed.
  
- **Case 2 – “Dirty” RCS**
  - Near worst possible realistic RCS and IR values representative of the ship in an operational environment conducting well deck and aviation operations.
  - SH-60s or MV-22s (whichever has higher RCS value) will be chained on the deck.
  - Stern gate will also be open with the well deck empty of LCACs and water.



# SCENARIO - ENVIRONMENT

- **Approach**
  - Provide representative sample space of environmental and other variables such as water vapor, specific humidity, particulates, temperature, air pressure, ducting, sea state 3 and associated wind direction, wind speed, wave height and wave direction, as well as sun angle.
- **Season**
  - Summer Scenario
  - Winter Scenario
- **Time of Day**
  - Shortly after Sunrise
  - Noon
  - Afternoon
  - Shortly before Sunset
  - Midnight
- **Sea State**
  - Established as Sea State 3 for All Scenarios

# SCENARIO - GEOGRAPHIES



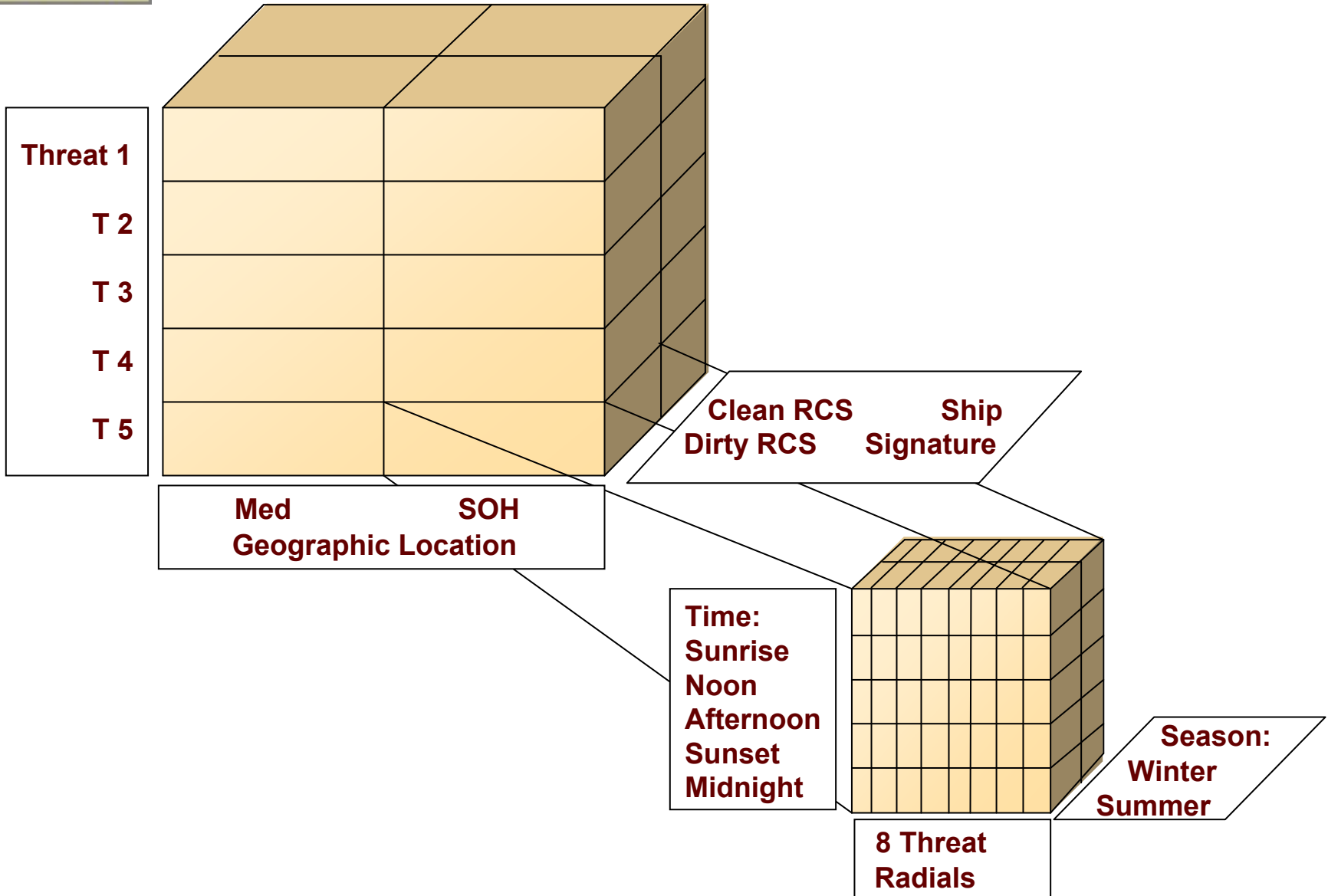
**Geography 1**  
**Open Ocean - Mid-Med**



**Geography 2**  
**Straits of Hormuz**



# SCENARIO VARIABLES





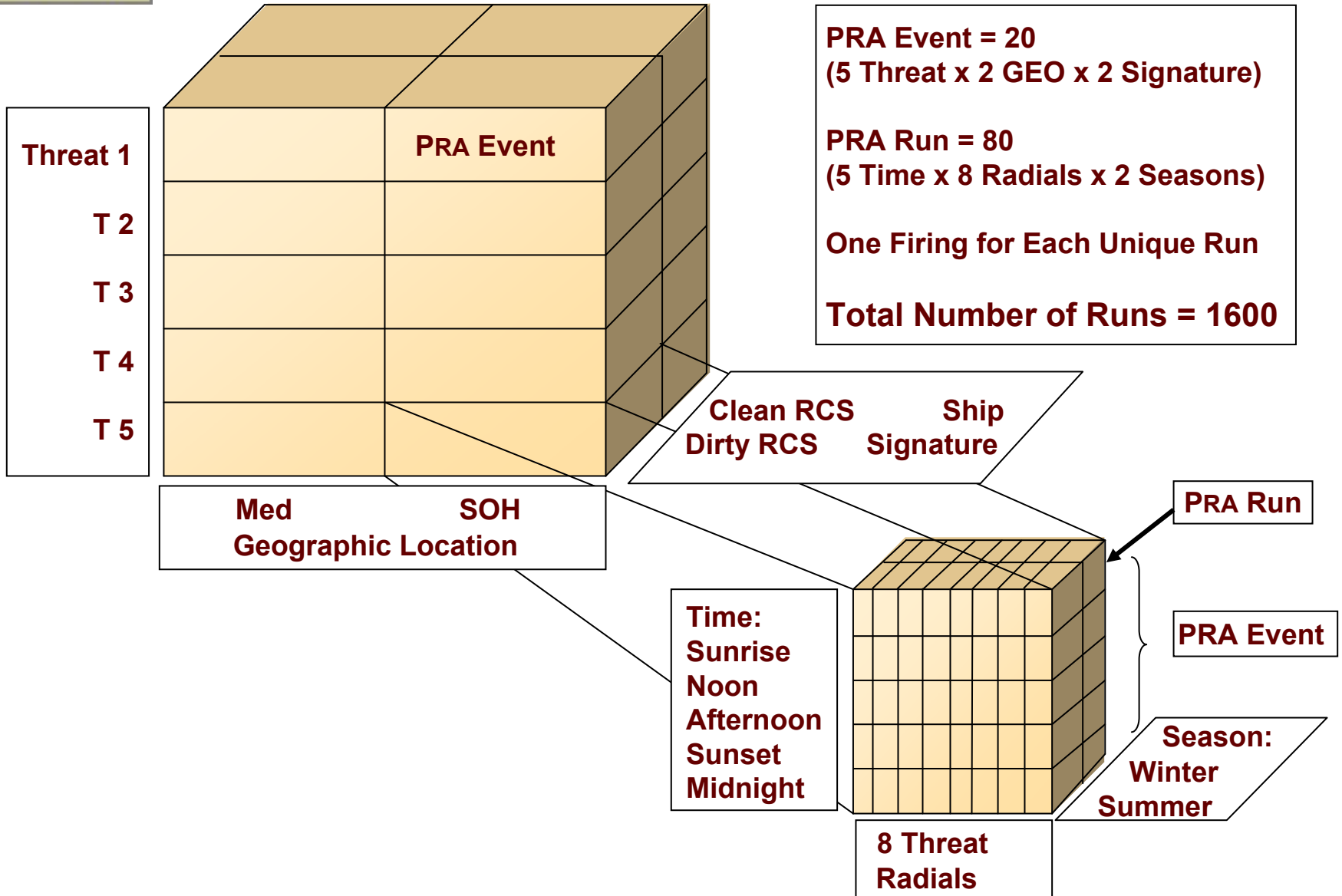
# ANALYSIS APPROACH

- **2 Geographies**
  - 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, Minimized RCS
  - Dirty, Open Well, Helo on Deck
  - Provides Large and Small Signatures
- **5 Threats**
  - T1R1, T2, T3, T5, T7
  - 8 Threat Bearings
  - 45 Deg Intervals
  - Provides Combat System Performance from all Directions

**PERFORM ONE RUN FOR EACH COMBINATION OF 6 VARIABLES  
STATISTICALLY A REPRESENTATIVE SAMPLING THROUGH THE SPACE**



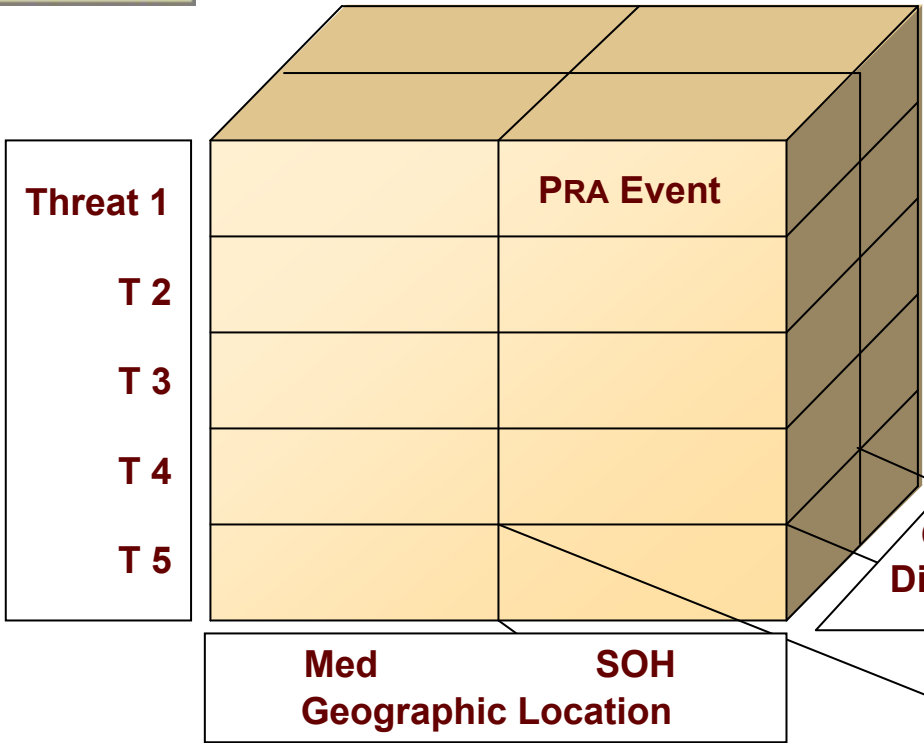
# TESTBED SAMPLE SPACE







# TESTBED PRA CALCULATIONS

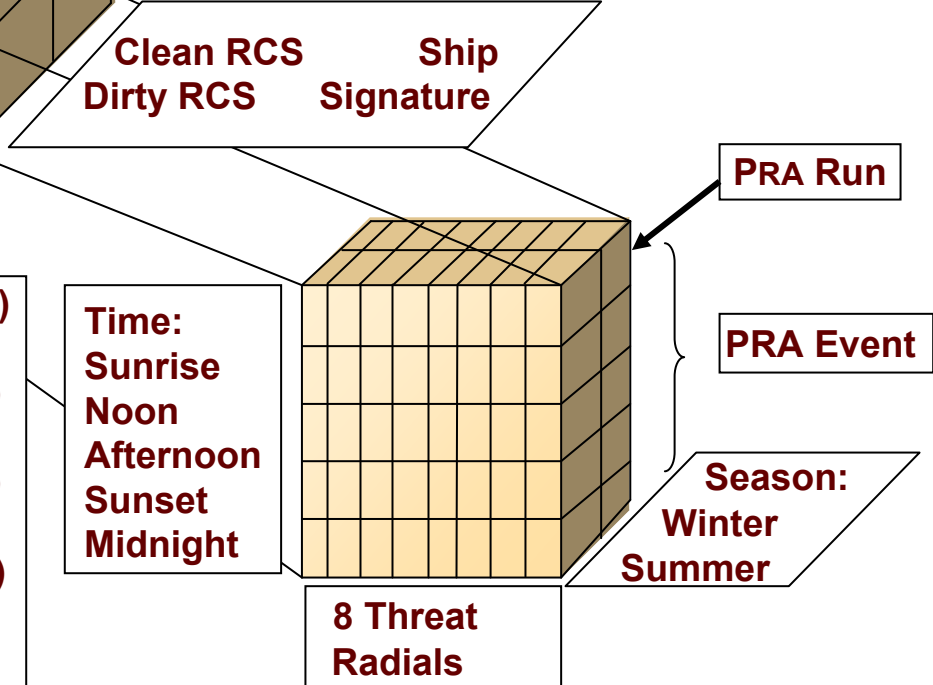


PRA Event = 20  
 (5 Threat x 2 GEO x 2 Signature)

PRA Run = 80  
 (5 Time x 8 Radials x 2 Seasons)

One Firing for Each Unique Run

Total Number of Runs = 1600



PRA (Event) =  $\frac{\# \text{ Successes}}{80}$  (20 PRA Values)

PRA (Threat) =  $\frac{\sum \text{ PRA Events}}{4}$  (5 PRA Values)

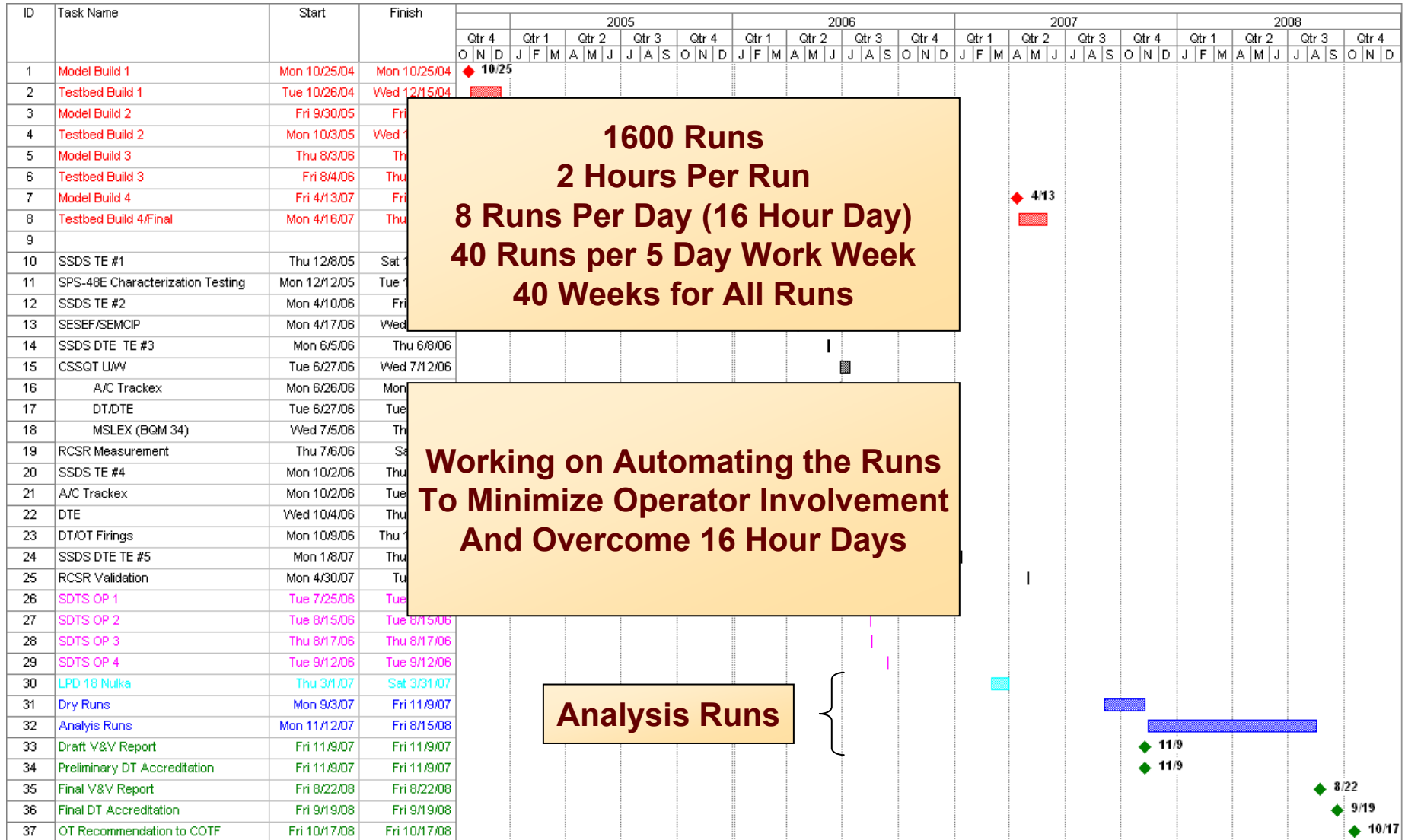
PRA (Geography) =  $\frac{\sum \text{ PRA Events}}{10}$  (2 PRA Values)

PRA (Ship Sig) =  $\frac{\sum \text{ PRA Events}}{10}$  (2 PRA Values)

PRA Overall =  $\sum \text{ PRA All Event}$  (1 PRA Value)



# TESTBED SCHEDULE



**1600 Runs  
2 Hours Per Run  
8 Runs Per Day (16 Hour Day)  
40 Runs per 5 Day Work Week  
40 Weeks for All Runs**

**Working on Automating the Runs  
To Minimize Operator Involvement  
And Overcome 16 Hour Days**

**Analysis Runs**

◆ 4/13

◆ 11/9  
◆ 11/9

◆ 8/22  
◆ 9/19  
◆ 10/17



# **ANALYSIS – KEY EVENTS**

- **Identify Key Events During Engagement**
  - **Sensor Performance, Sensor Messages, Weapons Orders, Weapons Performance, Engagement Outcome**
- **Data Collected and Displayed Live During Runs**
- **Used to Verify, Troubleshoot Testbed Performance**
- **Used to Calculate Various PRA Values**



# SUMMARY

## **Success for Testbed Development Based On:**

- Clearly Defined Requirements**
- Testbed Organization and Roles Well Understood**
- Documents Contain Necessary Information**
- Spiral Development and Schedule**
- Execute Phases of Simulation Development**
- Pragmatic Scenario Development**
- Systematic Analysis Approach**
- Collection, Manipulation and Presentation of PRA Values**



# BACKUP SLIDES