A Case Study of T&E Data Supporting A Simulation

LPD 17 PRA Testbed
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AVW Technologies
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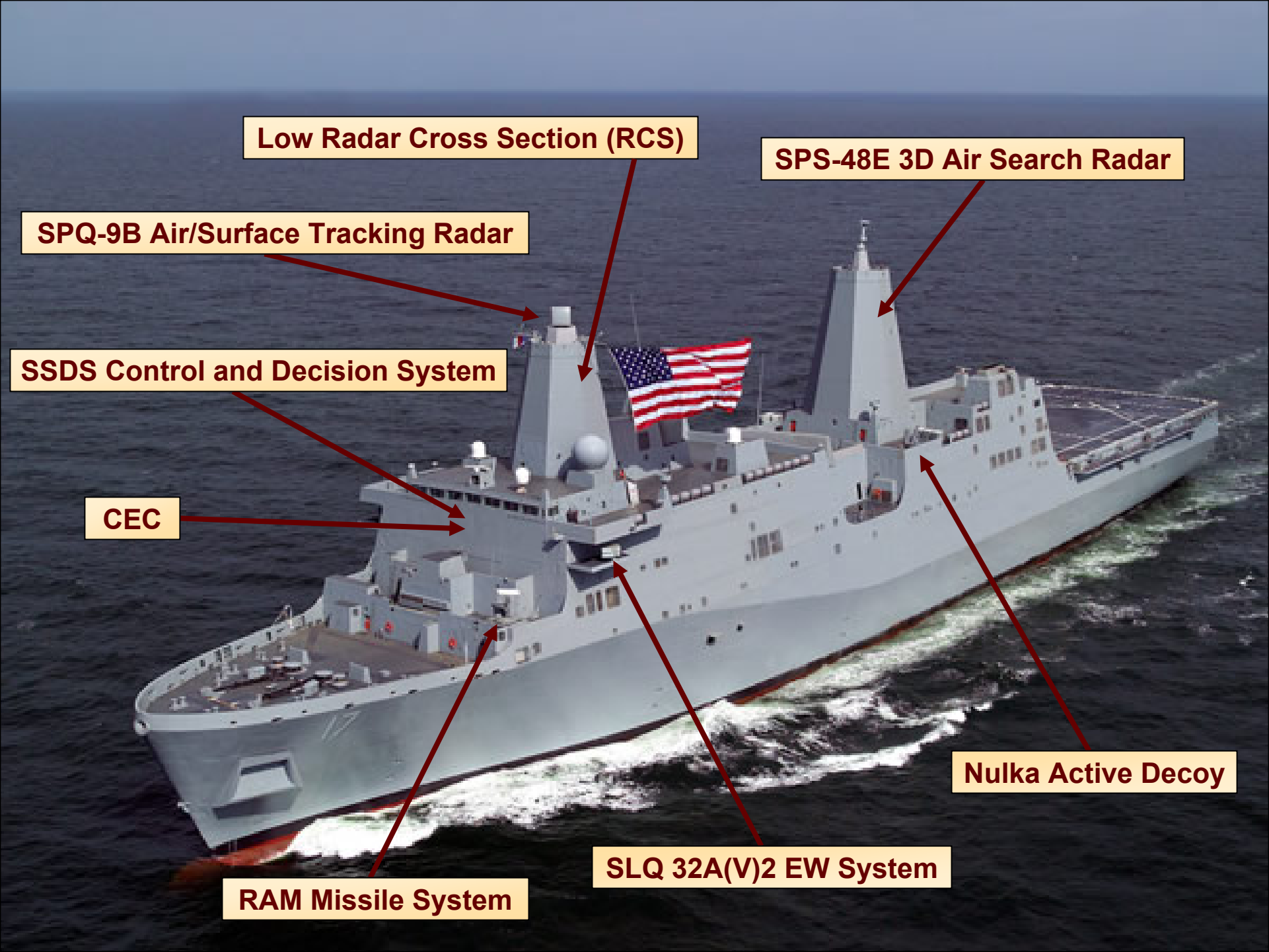
OVERVIEW

- LPD 17 San Antonio Ship Class
- LPD 17 Probability of Raid Annihilation (P_{RA}) Testbed Description and Architecture
- Historical vs Integrated Approach to Testing
- PRA Analysis
- Validating the LPD 17 Testbed
- Organizational Approach to Have T&E Data Support the LPD 17 PRA Testbed

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 (e.g., 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

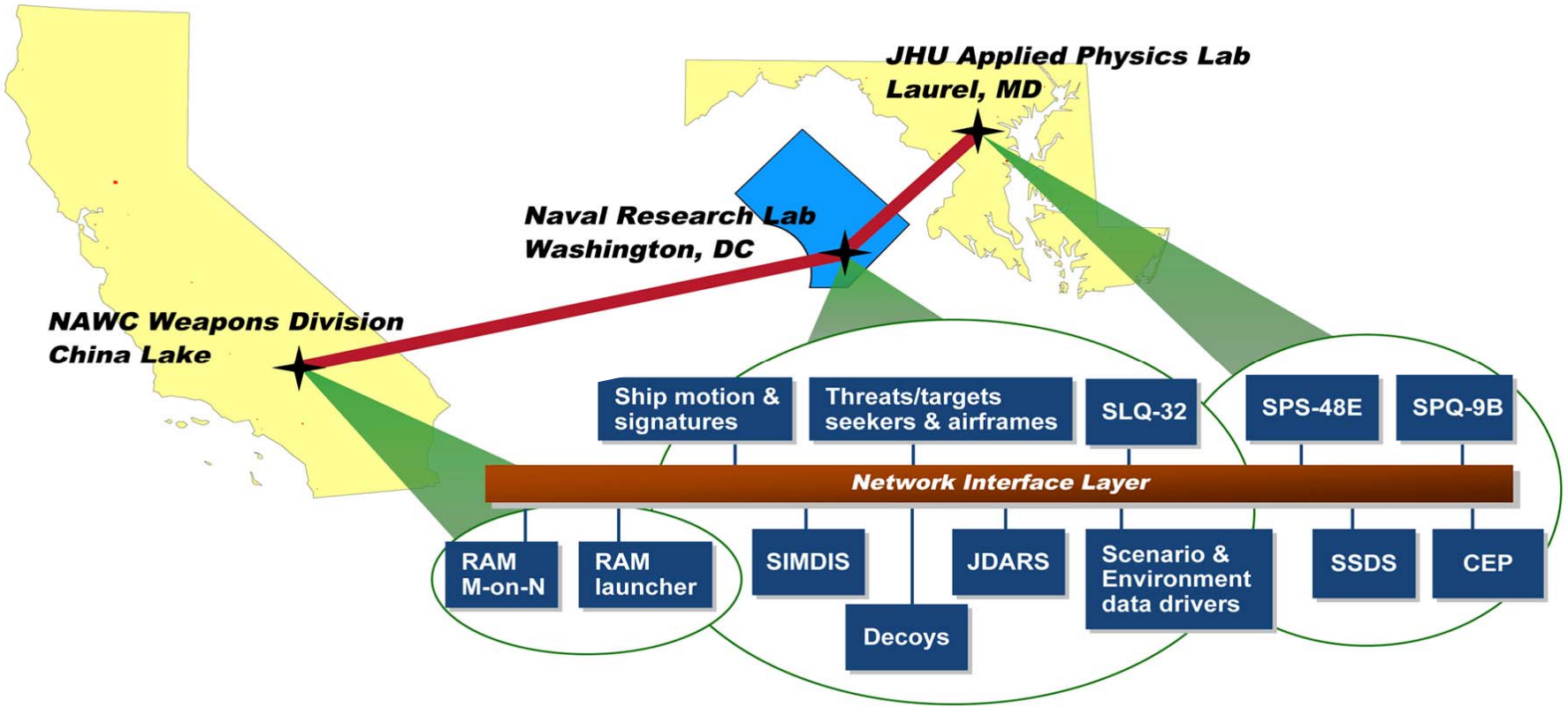

Low Radar Cross Section (RCS)
SPS-48E 3D Air Search Radar
SPQ-9B Air/Surface Tracking Radar
SSDS Control and Decision System
CEC
Nulka Active Decoy
SLQ 32A(V)2 EW System
RAM Missile System

BACKGROUND – P_{RA}

OBJECTIVE: ASSESS LPD 17's P_{RA} (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 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 anti-ship cruise missile (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}.

LPD 17 PRA TESTBED



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

NAVY CATEGORIES OF TESTING

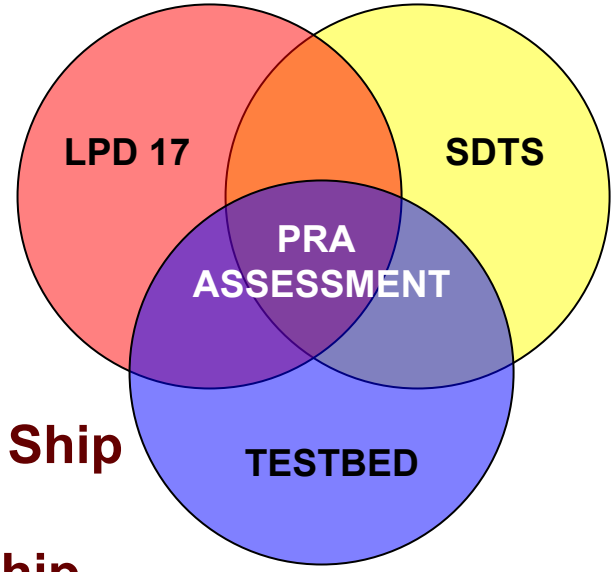
- Land Based Test Site (LBTS) Testing
- Lead Ship Testing/ Operational Testing (OT)
  - Each New Ship Class
  - Each New Combat System Element
- Self Defense Test Ship (SDTS) and Test Events
- PRA Modeling and Simulation

Navy Initiative Underway to Combine and Optimize Testing of New Systems To Eliminate Duplicate Efforts and To Achieve Cost Savings

NAVY INTEGRATED TESTING

- **Integrate Planning, Resourcing, Budgeting and Execution Across Combat System Variants and Associated Elements**
  - **No Longer Planned Independently by Each Program Office**
- **Optimization Efforts Include:**
  - **Maximize Combat System Ship Qualification Test (CSSQT) Resulting in Less DT, OT**
  - **Leverage Other Ship Class Combat System Testing**
  - **Testing of Common Variant**
  - **Maximize SDTS Testing Events**
  - **Maximize Use of M&S (PRA & Other Simulations)**

LPD 17 SOLUTION TO PRA



- **PRA Assessment is a Three Pronged Approach**
  - **Test Against Actual Ship (LPD 17)**
    - **Pro – Test Targets Against the Actual Ship**
    - **Con – Limited Firing Events, Cannot Fire Target Directly at Ship**
  - **Test Against SDTS**
    - **Pro – Targets and Actual Threats, Profile is Closer to SDTS**
    - **Con – Limited Representation of the Actual Ship, Limited Firing Events**
  - **Test Using M&S (LPD 17 PRA Testbed)**
    - **Pro – Can Runs Numerous Threats, Scenarios, Events**
    - **Con – Developmental Cost & Time, Limiting Assumptions**

OPTIMIZED TESTING – LPD 17

- CSSQT
  - Combat System Ship Qualification Testing (Prove Out the CS)
  - Maximize Use of Detect to Engage Sequence to Satisfy DT/ OT Requirements
  - Help Resolve PRA Measure of Effectiveness (MOE)
- Lead Ship/ Operational Testing
  - Tracking Exercises
  - Target Firings, Combat System Detect to Engage Sequence
  - Nulka Testing
  - Help Resolve PRA MOE
- SDTS
  - Target Firings, Engagement Analysis of Stressing Targets
  - Help Resolve PRA MOE
- PRA Testbed
  - Data Collection from Above Firings for Validation
  - PRA MOE Analysis (Testbed Accredited Specifically for PRA)
  - Feedback of Combat System Performance to Developers
  - Not Used for Preflight Predictions for Target Firings

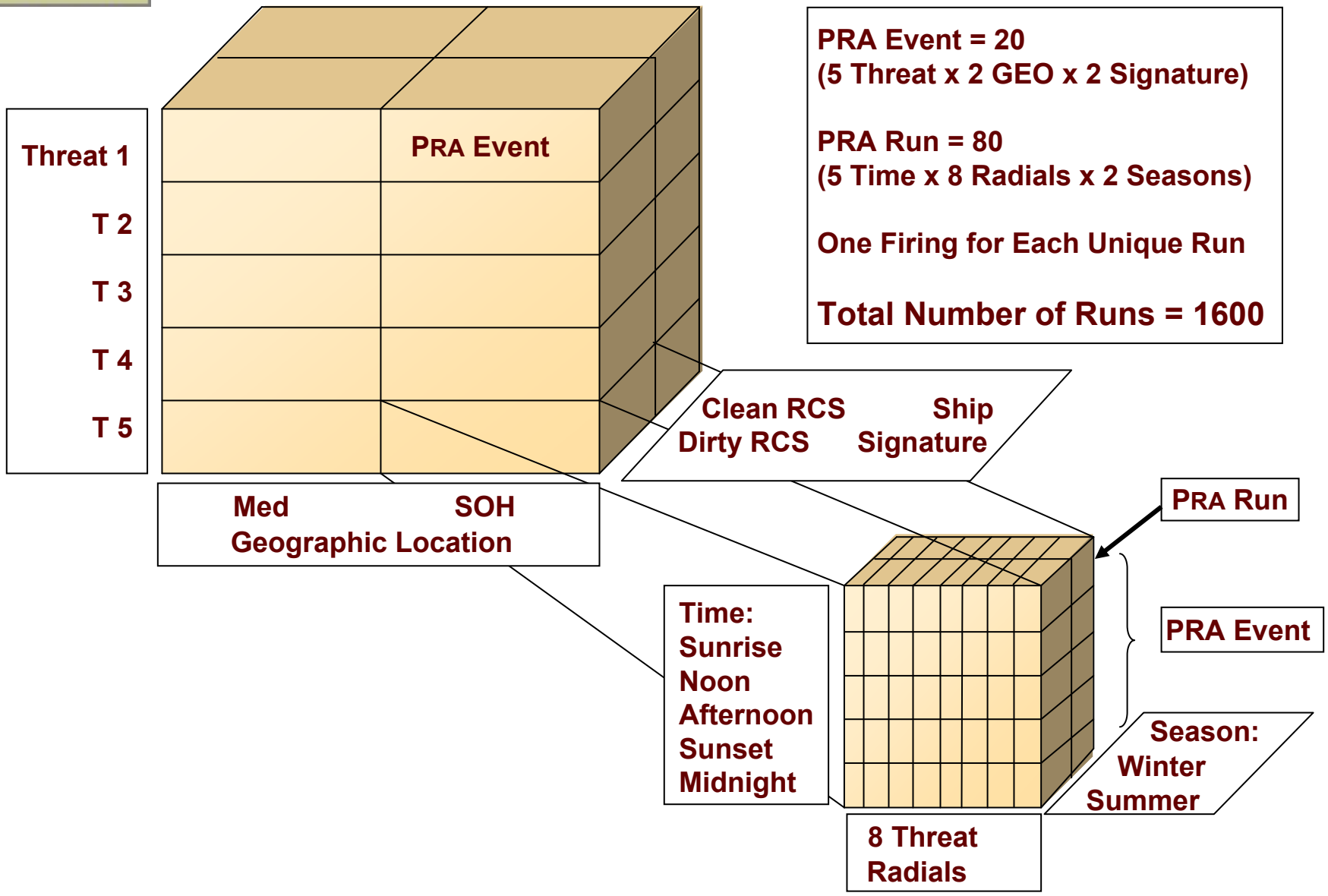
OPTIMIZING T&E AND M&S

- The 'Chicken and the Egg' Dilemma
  - You Need the Data to Accredit the Testbed to Perform the Preflight Predictions for the Live Fire Events that Get the Data
- M&S Optimizes Its Use of T&E Data
  - Use Tracking and Live Fire Data for Validation
  - Integrate Validation Results Into the Testbed
  - Validate and Accredit the Testbed
- T&E Data Optimizes Its Use of M&S
  - Live Fire Events Use Stand Alone Models For Preflight Predictions
  - Testbed Runs Gain Understanding of Combat Systems Sensitivities (Not Accredited to Perform Preflight Predictions)
  - In the Future – Accredit the Testbed to Perform Preflight Predictions (Although it Needs Live Fire Data to Accredit?)

LPD 17 PRA TESTBED

- Spiral Development
  - 4 Builds Over 4 Years
- Validation Activities
  - Compare Event With Replicated Event In the Testbed
    - CSSQT Event
    - Lead Ship/ OT Firings, Tracking Exercises
  - Integrated Validation Data Into Testbed
- Analysis Approach
  - 20 PRA Events (5 Targets, 2 Geographic Locations, 2 Ship Signatures)
  - 80 Runs Per PRA Event (5 Times of Day, 8 Threat Radials, 2 Seasons)
  - One Firing for Each Unique Run

TESTBED SAMPLE SPACE



TESTBED SCHEDULE

ID	Task Name	Start	Finish
1	Model Build 1	Mon 10/25/04	Mon 10/25/04
2	Testbed Build 1	Tue 10/26/04	Wed 12/15/04
3	Model Build 2	Fri 9/30/05	Fri 9/30/05
4	Testbed Build 2	Mon 10/3/05	Wed 11/16/05
5	Model Build 3	Thu 8/3/06	Thu 8/3/06
6	Testbed Build 3	Fri 8/4/06	Thu 8/24/06
7	Model Build 4	Fri 4/13/07	Fri 4/13/07
8	Testbed Build 4/Final	Mon 4/16/07	Thu 5/31/07
9			
10	SSDS TE #1	Thu 12/8/05	Sat 12/10/05
11	SPS-48E Characterization Testing	Mon 12/12/05	Tue 12/13/05
12	SSDS TE #2	Mon 4/10/06	Fri 4/14/06
13	SESEF/SEMCIP	Mon 4/17/06	Wed 4/19/06
14	SSDS DTE TE #3	Mon 6/5/06	Thu 6/8/06
15	CSSQT U/W	Tue 6/27/06	Wed 7/12/06
16	A/C Trackex	Mon 6/26/06	Mon 6/26/06
17	DT/DTE	Tue 6/27/06	Tue 6/27/06
18	MSLEX (BQM 34)	Wed 7/5/06	Thu 7/6/06
19	RCSR Measurement	Thu 7/6/06	Sat 7/8/06
20	SSDS TE #4	Mon 10/2/06	Thu 10/5/06
21	A/C Trackex	Mon 10/2/06	Tue 10/3/06
22	DTE	Wed 10/4/06	Thu 10/5/06
23	DT/OT Firings	Mon 10/9/06	Thu 10/12/06
24	SSDS DTE TE #5	Mon 1/8/07	Thu 1/11/07
25	RCSR Validation	Mon 4/30/07	Tue 5/1/07
26	SDTS OP 1	Tue 7/25/06	Tue 7/25/06
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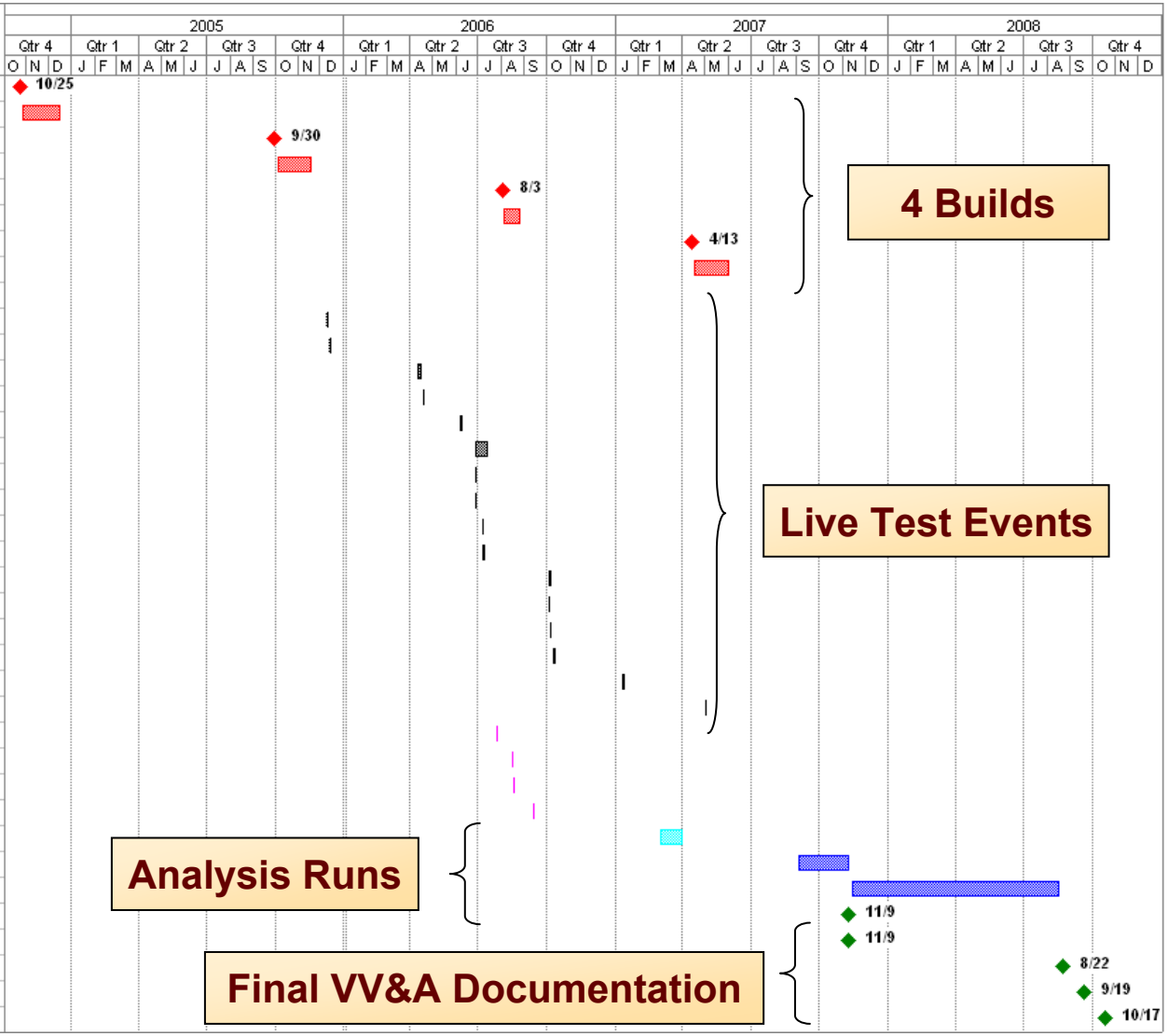
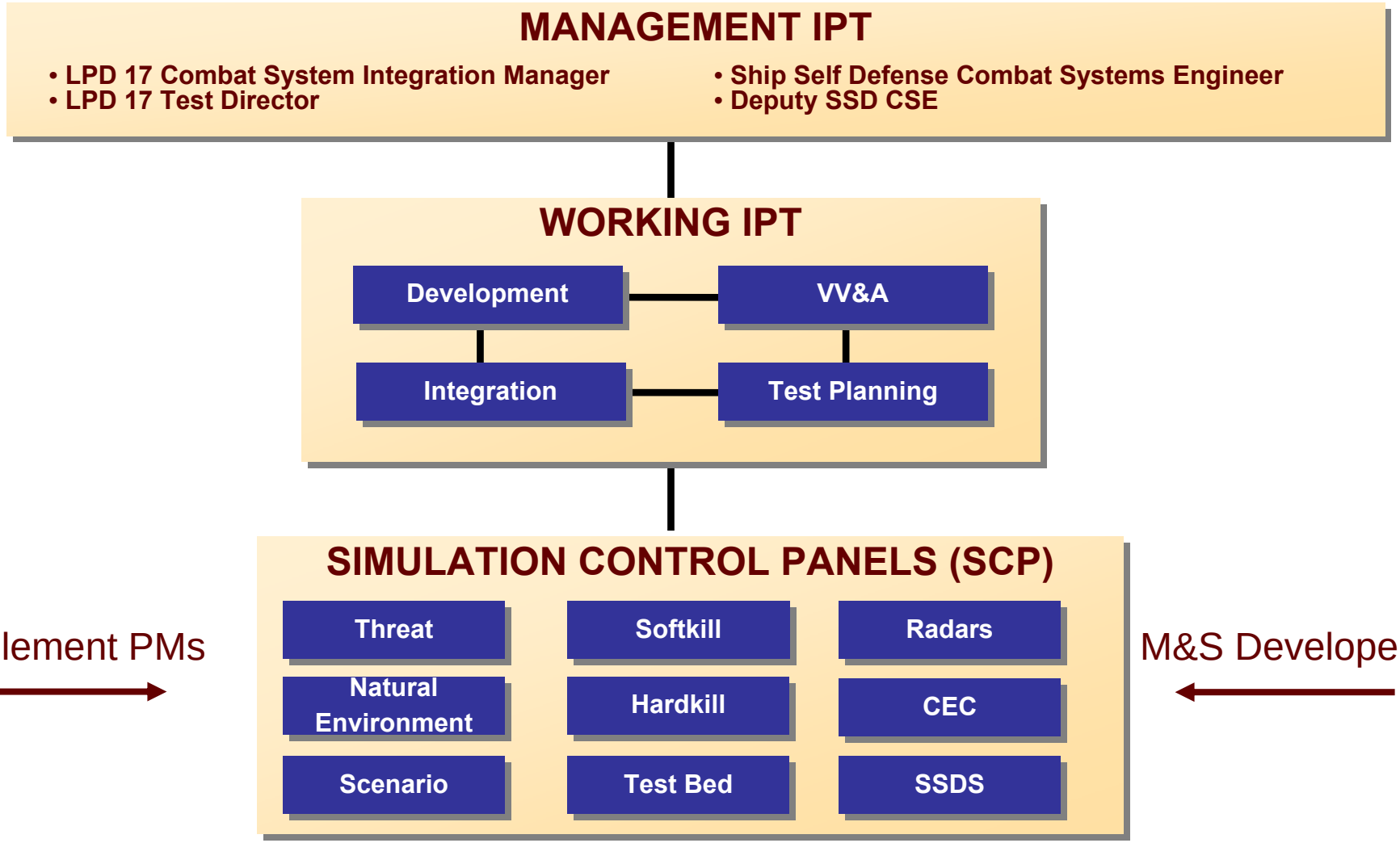
33	Draft V&V Report	Fri 11/9/07	Fri 11/9/07
34	Preliminary DT Accreditation	Fri 11/9/07	Fri 11/9/07
35	Final V&V Report	Fri 8/22/08	Fri 8/22/08
36	Final DT Accreditation	Fri 9/19/08	Fri 9/19/08
37	OT Recommendation to COTF	Fri 10/17/08	Fri 10/17/08



LPD 17 P_{RA} ORGANIZATION



ROLES & RESPONSIBILITIES

- PMS 317
  - Manage Funding
  - Drive Schedule
  - V&V Manager
  - DT Accrediting Authority
- PEO IWS CSE
  - Manage 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
  - Develop/ Integrate Models
- COMOPTEVFOR
  - Participates as the OT Accrediting Authority

COLLECTING VALIDATION DATA

- LPD 17 Organization
  - Dedicated Test Planning Position
    - Experienced Tester – Understands The Community
    - Knowledgeable in LPD 17 Testbed Process
- Data Collection Process
  - Supports the Generation of the Live Testing Data Needs
    - Determine What Testbed Developers Need
    - Put Needs into a Document that Live Testers Understand
  - Involved in the Actual Tests

Close Working Relationship with Live Testers
Vital in Collection of Needed Live Data

DATA COLLECTION PRINCIPLES

- Early Involvement
- Establish A Strong Working Relationship Between Developers and Testers
- Clearly Define Data Collection Needs
  - Understand What Developers Want
  - Articulate Into What Testers can Understand, Collect
- Effective Communication
  - Meetings
  - Working Documents
- Arrive at a Finalized Set of Events and Data Collection that will Support the Testbed Validation

AVW TECHNOLOGIES

A Case Study of T&E Data Supporting A Simulation

Questions?

AVW TECHNOLOGIES

BACKUP SLIDES

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

LPD 17 PRA TESTBED OVERVIEW

MANAGEMENT APPROACH:

Organization
Meetings
Documents
Schedule

TECHNICAL APPROACH:

Physics - Based
Non – Real Time
Distributed, RTI Solution
HLA Compliant
Spiral Development

SYSTEM OF SYSTEMS SOLUTION

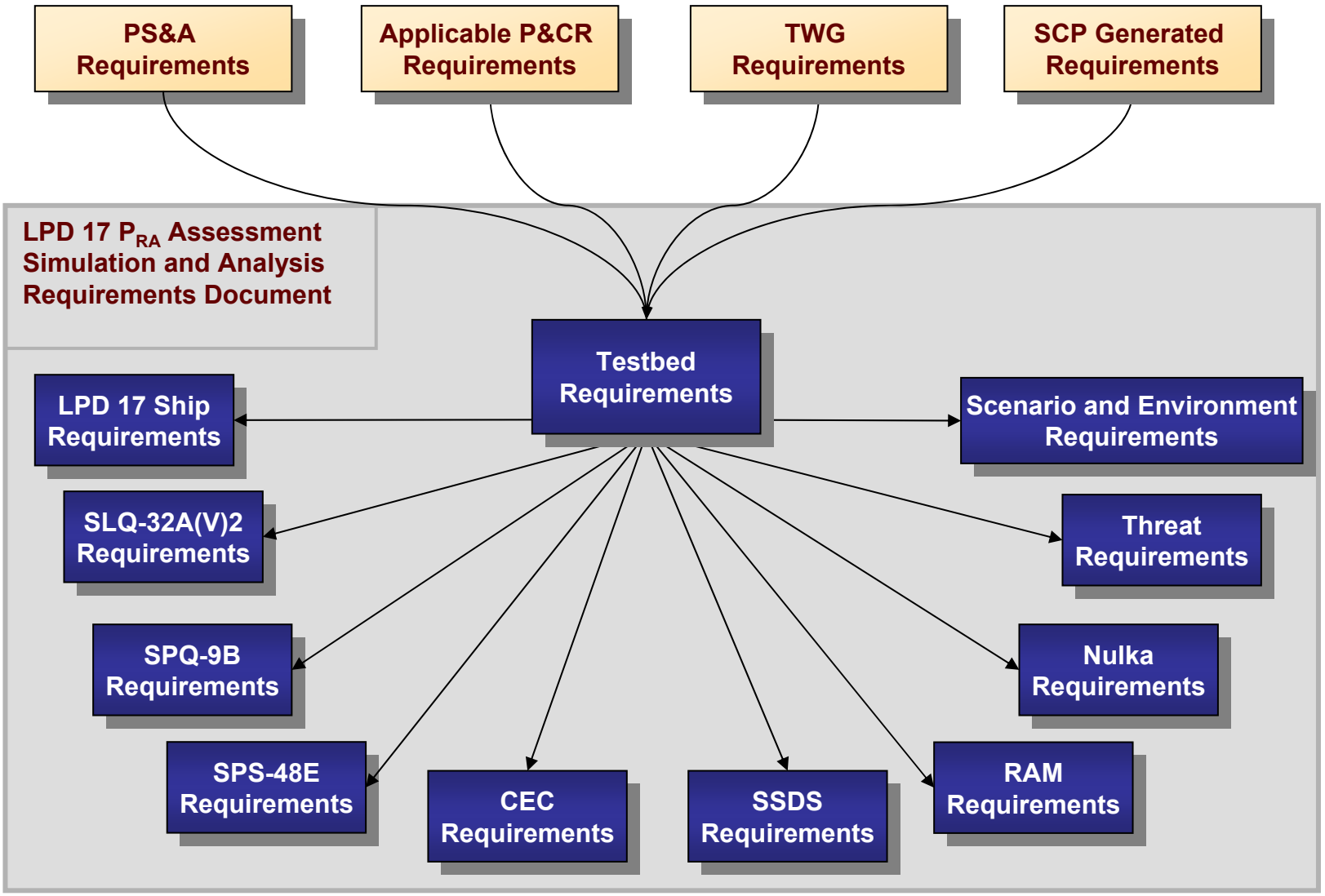
BOUND THE PROBLEM:

Testbed Requirements
Fidelity
Ship Configuration
Environment
Threat Types

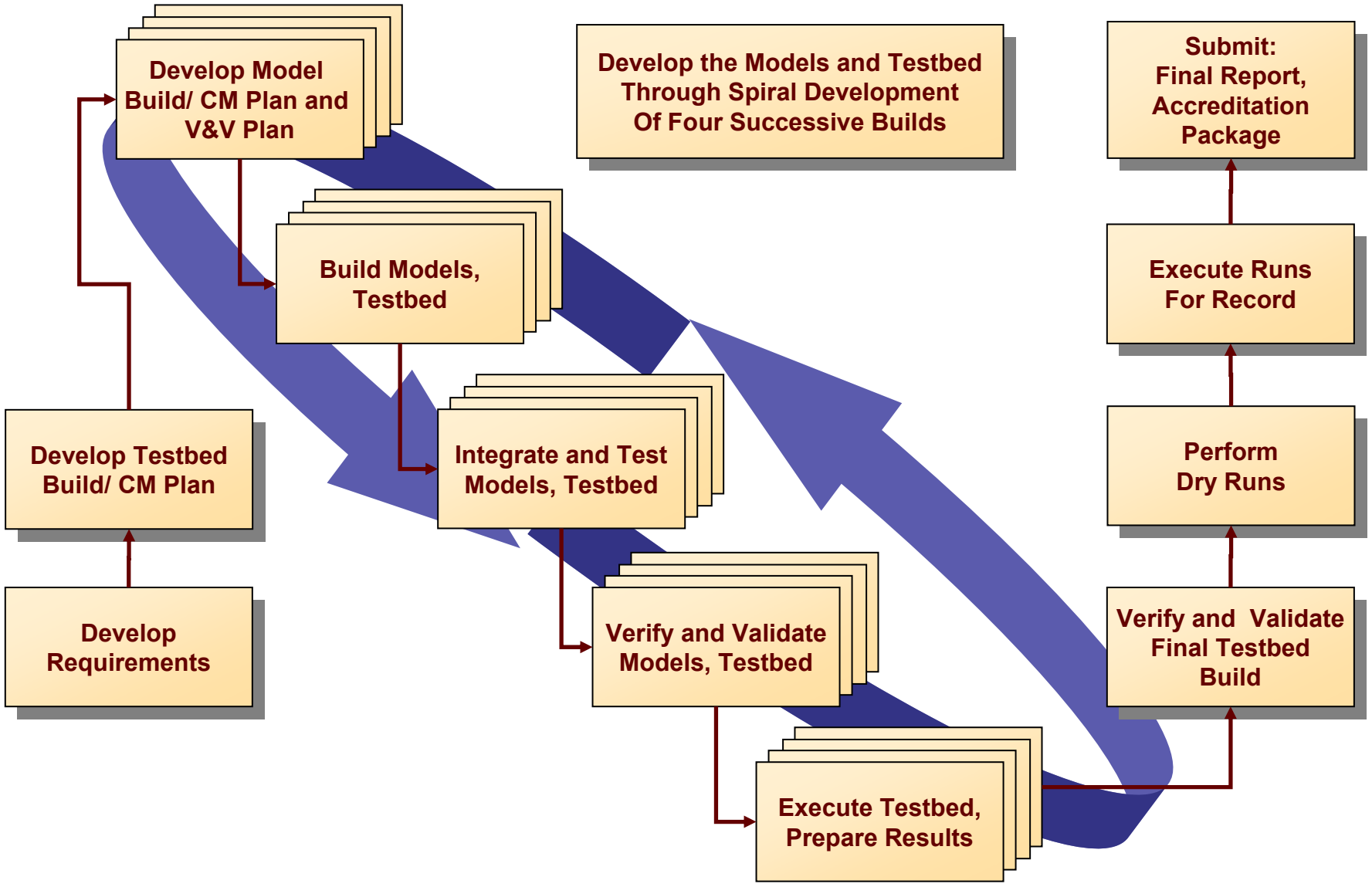
BOUND THE ANALYSIS:

Finite Number of Runs
f(Geographic Location
Ship Configuration
Season, Time of Day
Threat Types)

TESTBED REQUIREMENTS FLOW

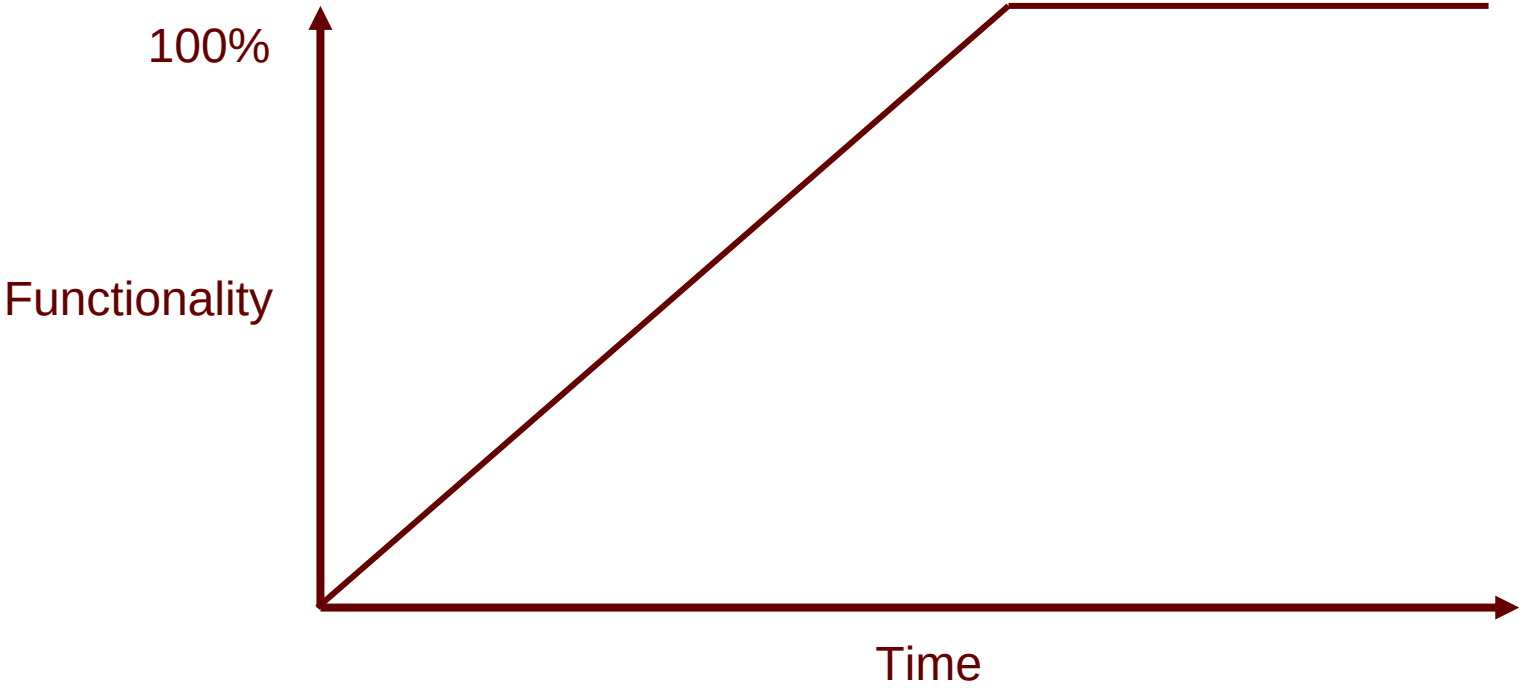


TESTBED SPIRAL DEVELOPMENT

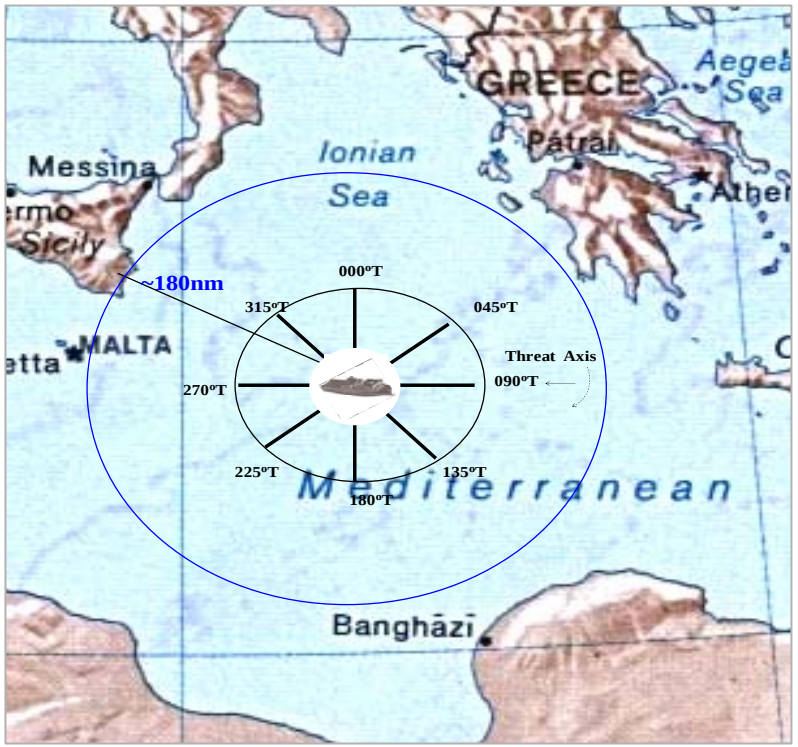


DEVELOPMENT TIMELINE

HOW ABOUT GROWTH LIKE THIS



SCENARIO - GEOGRAPHIES



Geography 1
Open Ocean - Mid-Med

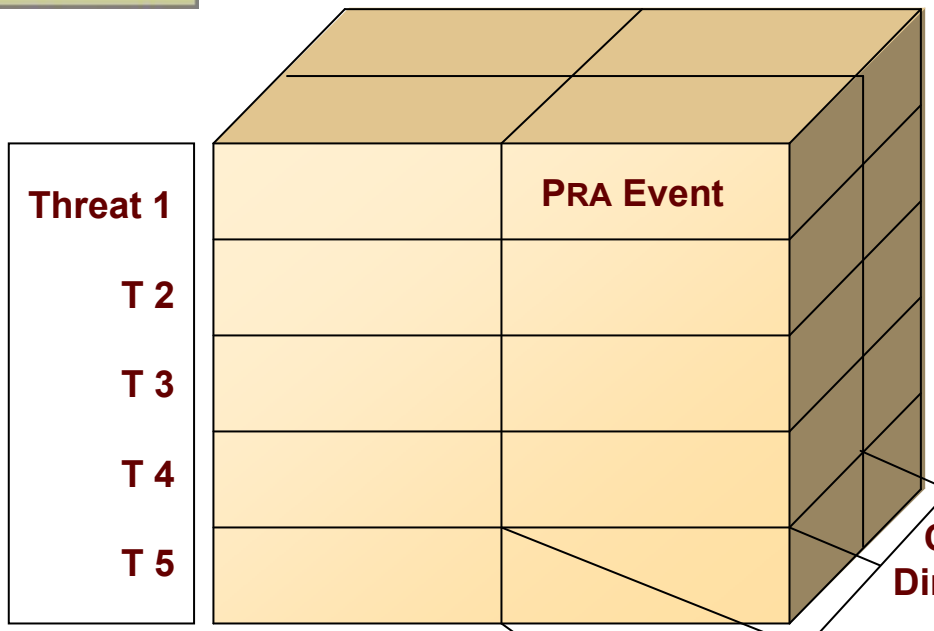
Geography 2
Straits of Hormuz

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 REPRENTATIVE SAMPLING THROUGH THE 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

Clean RCS
Dirty RCS

Ship
Signature

Med
SOH
Geographic Location

PRA Run

PRA Event

Time:
Sunrise
Noon
Afternoon
Sunset
Midnight

Season:
Winter
Summer

8 Threat
Radials

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

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

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

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

PRA Overall = Σ PRA All Event (1 PRA Value)

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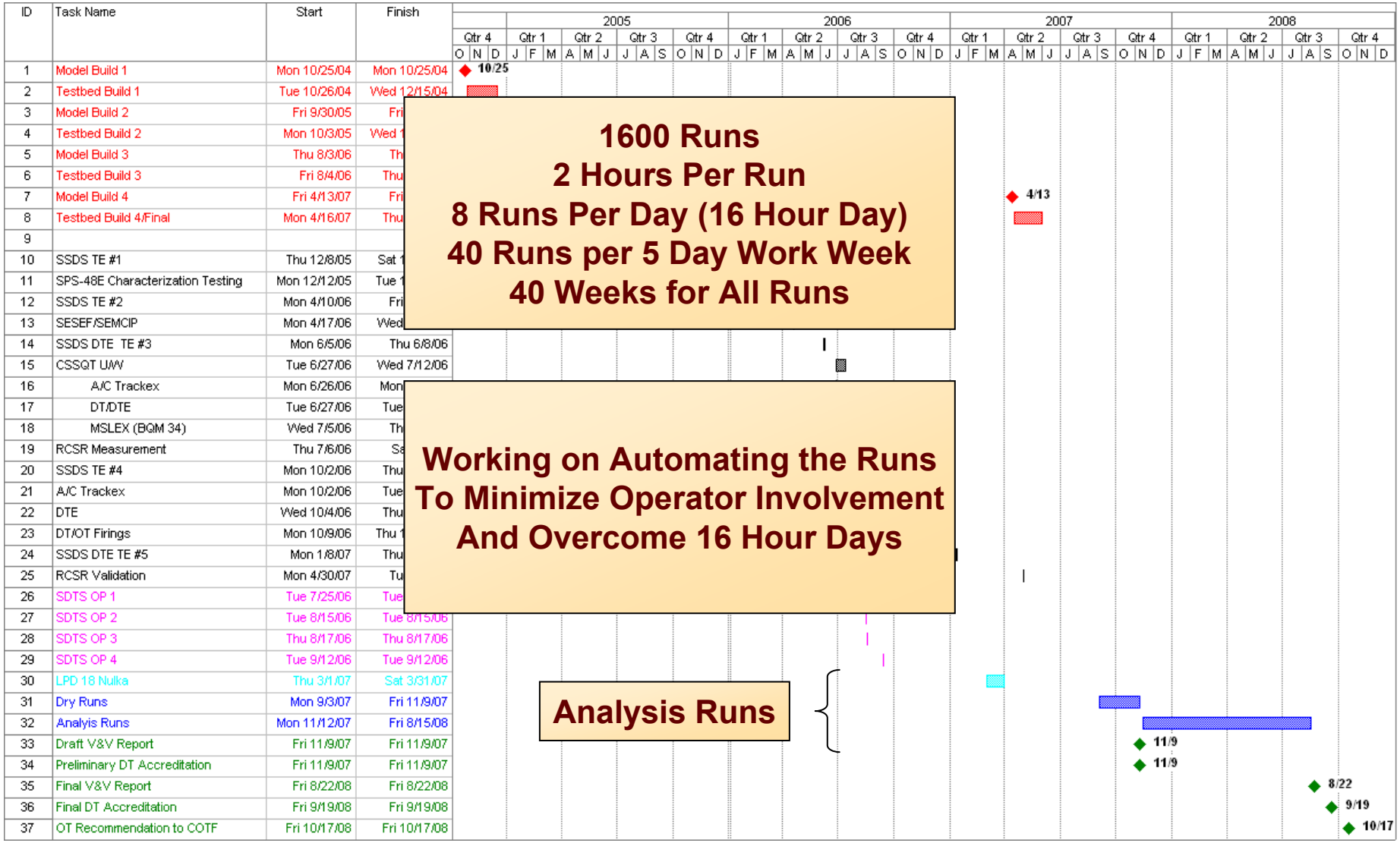

1600 Runs
2 Hours Per Run
8 Runs Per Day (16 Hour Day)
40 Runs per 5 Day Work Week
40 Weeks for All Runs

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

Analysis Runs