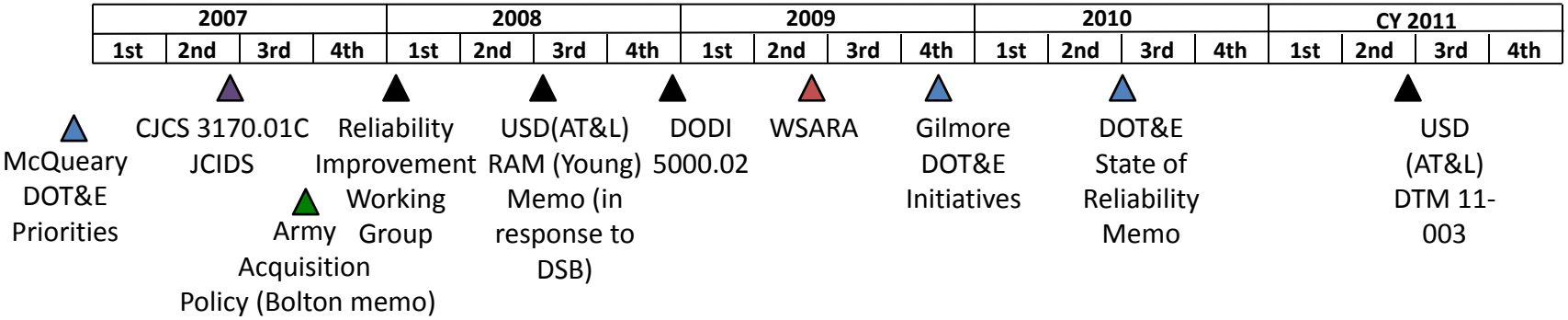
# Key Issues in Reliability Growth

Honorable Dr. Michael Gilmore
Director, Operational Test & Evaluation

Presentation to National Academy of Science
Panel on the Theory and Application of Reliability Growth Modeling in Defense Systems
September 22, 2011

# DoD Steps Taken to Improve Reliability

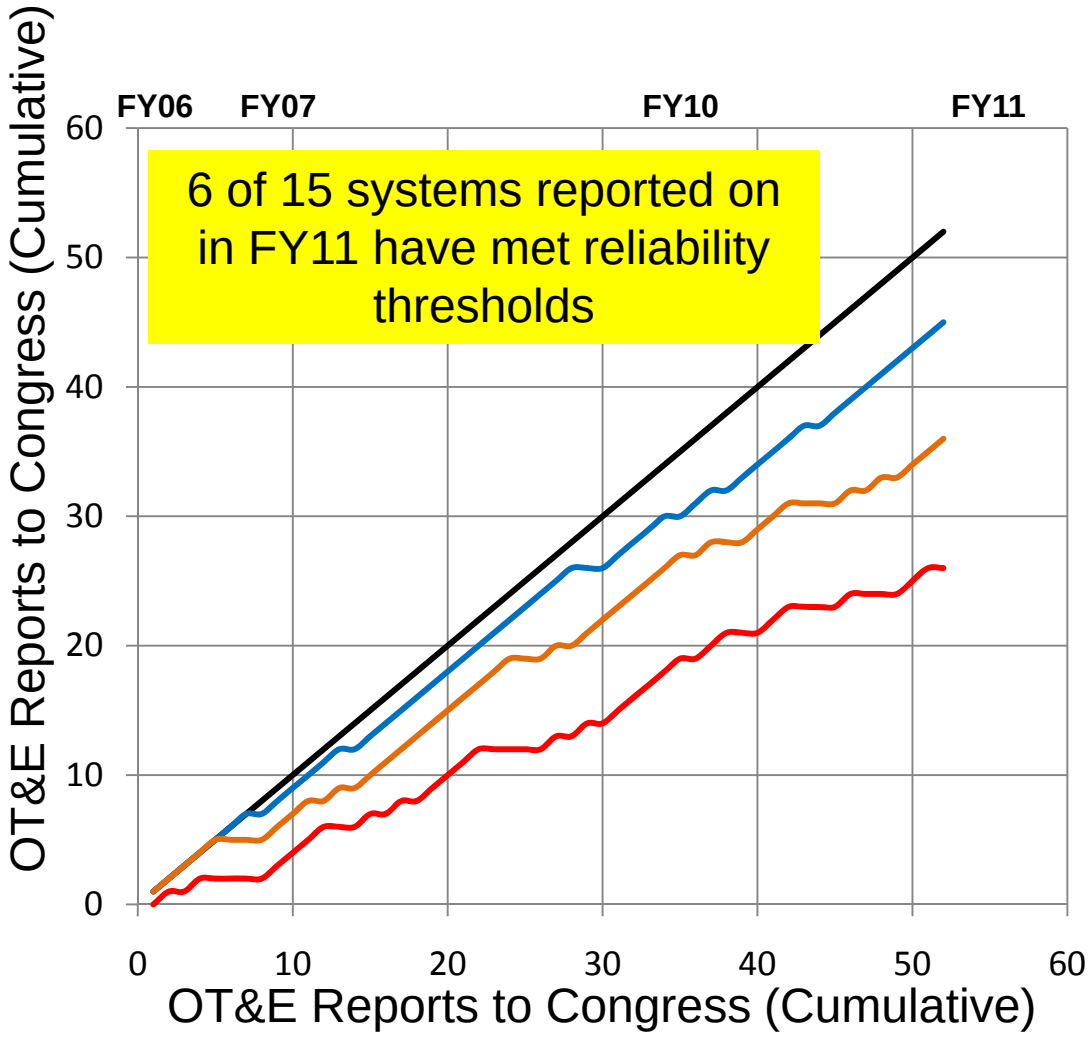


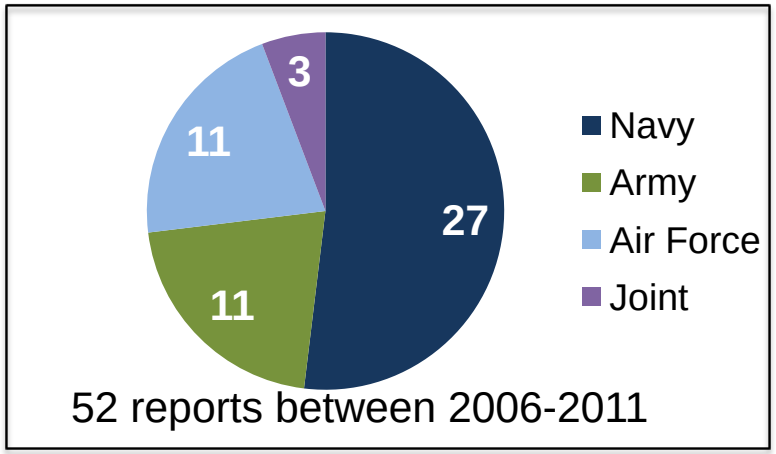

- Reliability (MTBF) is a key factor in O&S costs of systems
  - Additional burden to user in unscheduled maintenance and down time

- DOT&E top priority since 2006 has been to improve suitability of fielded systems, in addition:
  - Army Acquisition Policy
  - Joint Staff Directive
  - Defense Science Board Study
  - Congressional Language
  - USD (AT&L) policy updates

DoD needs systems that are effective when needed, not just effective when available

# Trends in Reliability




IDEAL
EFFECTIVE
SUITABLE
RELIABLE

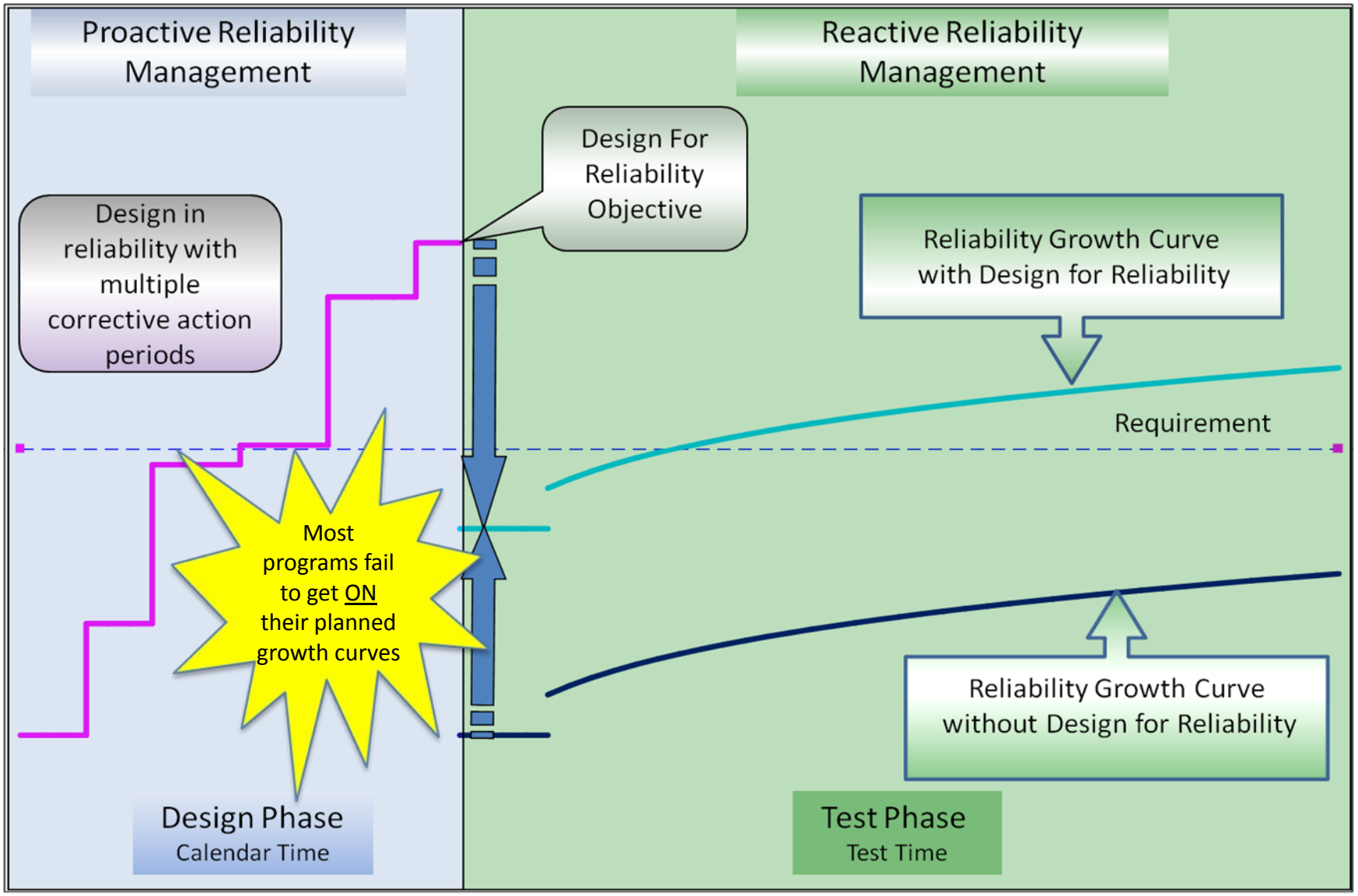
Overall since 1985:
30% of 170 Systems Reported Not Suitable

# Reliability Program Standard

- In 1998, DoD canceled Mil-Std-785B: *Reliability Program for Systems and Equipment Development and Production*
  - Originally written in 1969, last updated 1980
  - Industry continues to follow *-785* tasks (reactive vice proactive)
    - Approx 30% reliability from design
    - Approx 70% reliability from growth tests (after design is completed)

- In 2008, OSD/DDR&E(SE) adopted the ANSI/GEIA-STD-0009, which promotes four objectives:
  - Understand customer/user requirements and constraints
  - Design for Reliability (DfR) and re-design for reliability
  - Produce reliable systems
  - Monitor and assess user's experienced reliability

# Reliability Management



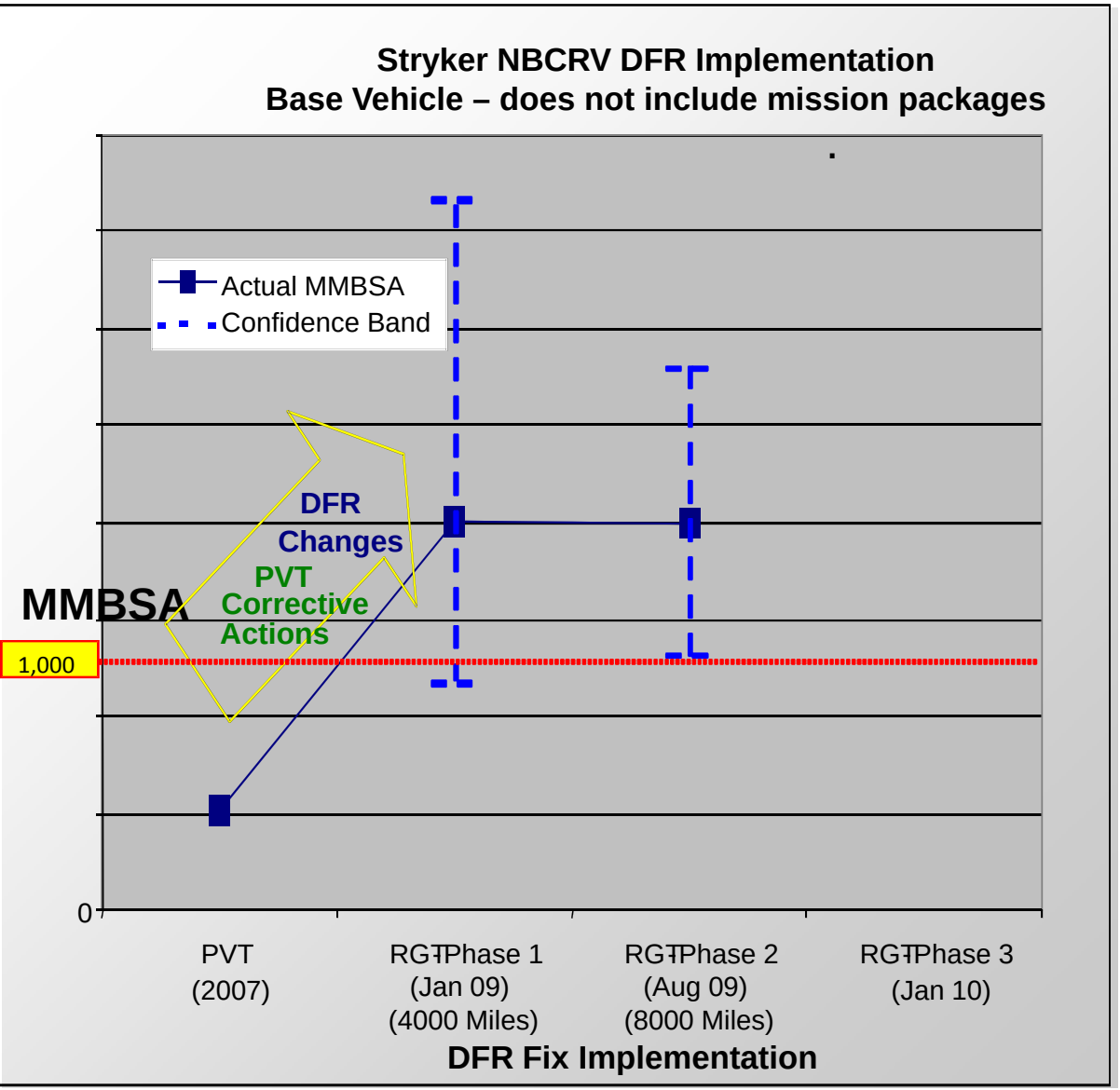
# Examples of Programs using DfR

- Small Diameter Bomb II (Raytheon)
  - Completed CDR
  - Accelerated life (HALT) and test-analyze-and-fix (TAAF) planned
  - Using formal reliability growth methodology

- Stryker Nuclear Biological Reconnaissance Vehicle (NBCRV) (GDLS)
  - Re-design following Nunn-McCurdy breach
  - Exposed and mitigated failure modes by understanding the life cycle and environmental loads
  - Successfully demonstrated operational requirement in OT

- Ground Combat Vehicle (BAE and GDLS)
  - Competitive two-year Tech Demo with two contractors
  - Following similar DfR as Stryker NBCRV

# Stryker NBCRV Reliability Growth

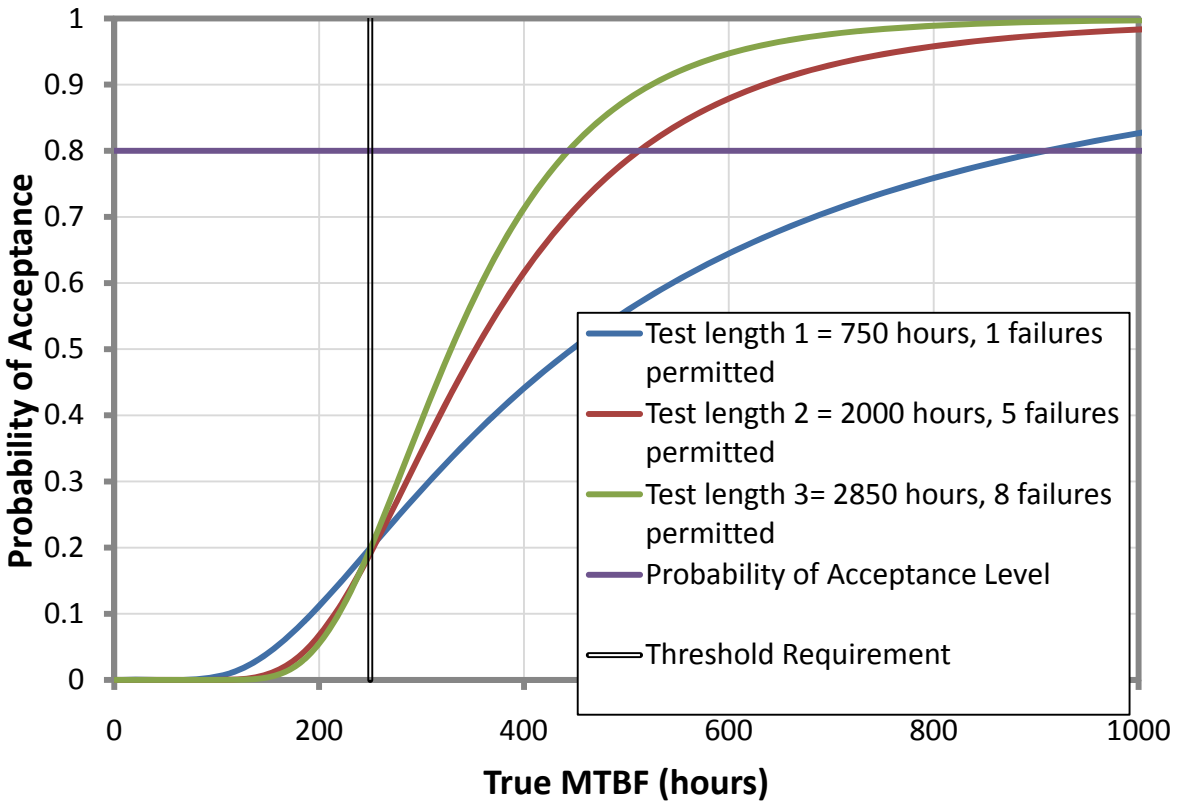



- Production Verification Testing (PVT) was halted prematurely due a large number of System Aborts
- System contractor implemented **Design For Reliability** to improve base vehicle reliability (2007-2008)
- NBCRV underwent 8000 mile Reliability Growth Test (RGT) and demonstrated dramatic improvement in reliability between PVT and RGT
- Requirements drove the focus of DFR, but requirements addressed only the base vehicle and not the NBC sensors
- DFR is a powerful tool to improve reliability, but must address entire system to be effective

# Reliability Growth in TEMPS

- Review of all 353 Programs on 2010 T&E oversight
  - Including 151 programs with approved TEMPS
  - 90% programs with TEMPS approved since 2008 plan to collect and report reliability data
- Comparison of programs that completed a TEMP before and after June 2008 (when OSD began initiatives to improve reliability) indicate improvement in several areas. Since 2008, programs are more likely to:
  - Have an approved System Engineering Plan
  - Incorporate reliability as an element of test strategy
  - Document reliability growth strategy in the TEMP and include reliability growth curves in TEMPs
  - Establish reliability-based milestone or OT entrance criteria
  - Collect and report reliability data.
- No significant improvement yet in systems meeting reliability thresholds
  - No evidence of programs using reliability metrics to ensure growth is on track
  - Systems continue to enter OT without demonstrating required reliability
  - 50% of programs with time scheduled to implement corrective actions met reliability thresholds compared to only 22% programs without corrective action periods

# Test Design Concepts




Simple 3x requirement rule of thumb underestimates risk by only allowing for one failure

- **The risk associated with incorrect decisions (accepting a unreliable system or rejecting a reliable system) need to be considered in test planning.**

- **Operating Characteristic (OC) curve analysis should be used to mitigate risk in demonstrating reliability requirement.**
  - Used to determine risks (Type I and Type II errors)
  - Comparison across multiple curves helps gauge sample size as a function of allowable failures and risk.

- **Risks for reliability demonstration tests should be evaluated quantitatively, and balanced against constraints for cost and schedule**

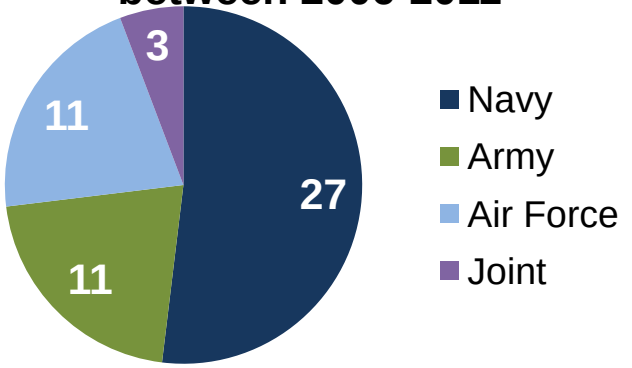
# Significant DoD Actions Since 2008 Defense Science Board Report

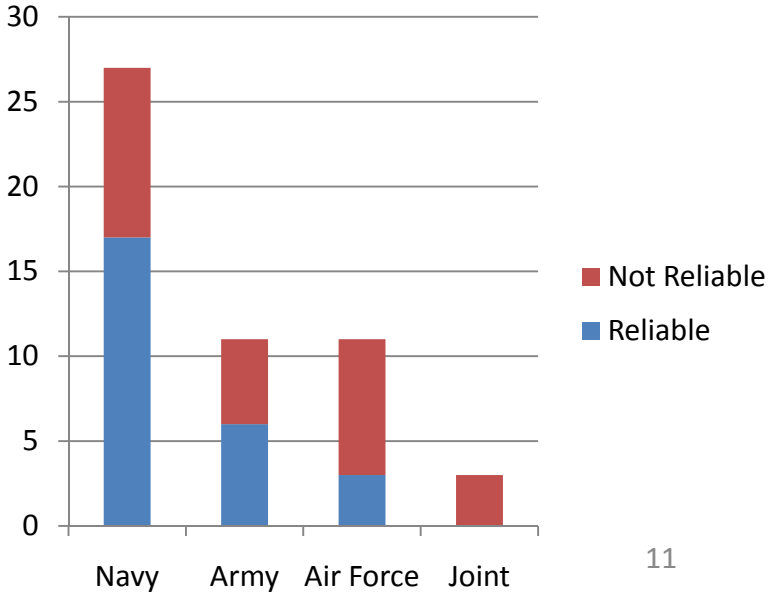
- Systems Engineering Forum Established
  - DOT&E and AT&L Systems Engineering with Service SE Executives
  - Included monthly updates from each Service on reliability improvement action items (These monthly updates drove the action at the working level)
- DOT&E sponsored Reliability Growth Analysis (ReliaSoft RGA) training (Dr. Ernest Seglie championed this effort)
  - Presented by Dr. Larry Crow (Developer of the Crow (AMSAA) model)
  - Attended by DOT&E staff and Service R&M and T&E personnel
- Reliability Senior Steering Group
  - Established in response to the 18 DEC 09 DOT&E letter to USD(AT&L)
  - DoD Leaders and Service Acquisition Executives
  - Three Working Groups comprised of DOT&E, AT&L and Service participants
  - Primary product: DTM 11-03 – Reliability Analysis, Planning, Tracking, and Reporting
- AT&L's DASD(SE)Mission Assurance now has a dedicated position for R&M Engineering
  - Provides recommendations and advice based on experience
  - Chairs the Service R&M Engineering Leads quarterly working group

# Service Actions Since 2008 Defense Science Board Report

- Army
  - Reliability Growth Planning Curve goes into EMD contracts
  - Execute DfR program before MS B
  - Early EMD reliability test threshold
  - Army Center for Reliability Growth
  - Training for Army, OSD and other services
- Navy
  - Established Dir, R&M Engineering position in ASN(RD&A) and working groups established at the DON and SYSCOM levels
  - Established a network based Integrated Reliability Software Suite for all DON use (includes Reliasoft)
  - NAVAIR ‘s mature R&M Engineering competency has over 200 R&M engineers and technicians; they never stopped; NAVSEA, SPAWAR and MARCOR are rebuilding
- Air Force
  - AFMC sponsored training short courses in reliability
  - System Engineering Plans and procedures for analysis and classification of potential failure modes
  - Risk Identification, Integration, and Ilities (R3I) guidebook

**Distribution of 52 DOT&E reports to Congress between 2006-2011**



# BACKUPS

# OT&E Reports sent to Congress between 2006 - 2011

| |
|---|
| Small Diameter Bomb Increment One (SDB) |
| Global Broadcast Service (GBS) Space System |
| Air Force Mission Planning System (MPS) Increment II F-15 |
| MQ9 Reaper Unmanned Aircraft System (UAS) |
| Air Force Mission Planning System (MPS) Increment III (F-16) |
| B-2 Radar Modernization Program (RMP) Mode Set One (MS 1) |
| C-5 Reliability Enhancement and Re-engining Program (RERP) |
| Miniature Air-Launched Decoy (MALD) |
| C-27J Joint Cargo Aircraft (JCA) |
| RQ-4B Global Hawk Block 30 |
| Space-Based Surveillance System (SSBS) |
| Common Missile Warning System |
| Small Unmanned Aerial System |
| Ch-47F Block II Cargo Helicopter |
| UH-72A Lakota Light Utility Helicopter (LUH) |
| M31A1 Guided Multiple Launch Rocket System - Unitary |
| Mine Resistant Ambush Protected (MRAP) |
| M915A5 Truck Tractor, Line Haul |
| Mine Resistant Ambush Protected (MRAP) - All-Terrain Vehicle (M-ATV) |
| Suite of Integrated Radio Frequency Countermeasures (SIRFC) |
| Excalibur Increment 1A-2 |
| Warfighter Information Network - Tactical (WIN-T) Increment 1a |
| Joint Biological Agent Identification and Diagnostic System (JBAIDS) |
| Joint Chemical Agent Detector (JCAD) |
| Joint Biological Point Detection System (JBPDS) |

| |
|---|
| MH-60R Multi Mission Helicopter |
| Surface Electronic Warfare Improvment Program (SEWIP) |
| APG-79 AESA Radar |
| UH-60M Black Hawk Utility Helicopter |
| Common Submarine Radio Room (CSRR) |
| T-AKE Lewis & Clark Class of Auxiliary Dry Cargo Ships |
| Common Broadband Advanced Sonar System (CBASS) Phase I Torpedo |
| ALQ-99 Low Band Transmitter System |
| Ohio Class Nuclear Power guided Missile Submarine (SSGN) |
| USMC H-1 Upgrades (UH-1Y) |
| MH-60S Block 3A Armed Helicopter Weapon System |
| Surface Electronic Warfare Improvement Program (SEWIP) |
| EA-18G Airborne Electronic Attack (AEA) Aircraft |
| Acoustic Rapid Commercial Off-the-Shelf (COTS) Insertion (A-RCI) AN/BQQ-10(V) Sonar System |
| Virginia Class Submarine |
| DoN LAIRCM |
| Vertical Launch Anti-Submarine Rocket (ASROC) with VLA Mk 54 |
| CV-22 Osprey |
| USS San Antonio (LPD 17) Class Amphibious Transport Dock Ship |
| USMC H-1 Upgrades (AH-1Z) |
| TB-34 Next Generation Fat-Lined Towed Array |
| MH-60R Multi Mission Helicopter and MH-60S Multi Mission Combat Support Helicopter |
| Multifunctional Information Distribution System Joint Tactical Radio System (MIDS JTRS) |
| Improved (Chemical Agent) Point Detection System - Lifecycle Replacement (IPDS-LR) |
| Low Cost Conformal Array (LCCA) |
| Integrated Defensive Electronic Countermeasures (IDECM) |
| Acoustic-Rapid COTS Insertion (A-RCI) BYG-1 Advanced Processor Build-07 (APB-07) |

# Companies that Advocate Use of Design for Reliability Activities

The companies below have robust and proactive enterprise reliability programs comprised of engineering processes and activities, like those described in ANSI/GEIA-STD-0009.

The bannered entries are using ANSI/GEIA-STD-0009.

Allison Transmission

BAE Systems, Global Combat

Boeing - Phantom Works

Ford Electronics Division

General Dynamics C4 Systems

General Dynamics Land Systems

General Motors Military Vehicle Division

Harris Corporation

Honeywell Aerospace and Defense

Lockheed Martin

Northrop Grumman Corporation

QinetiQ North America

Raytheon Missile Systems

Rockwell Collins, Inc.

The Boeing Company

Toyota Motor Corporation