Advanced EHF Mission Control Segment (MCS) Software Maturity

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Agenda

- System Overview
- Introduction
- Reliability Growth Model Analysis
- Process Improvements

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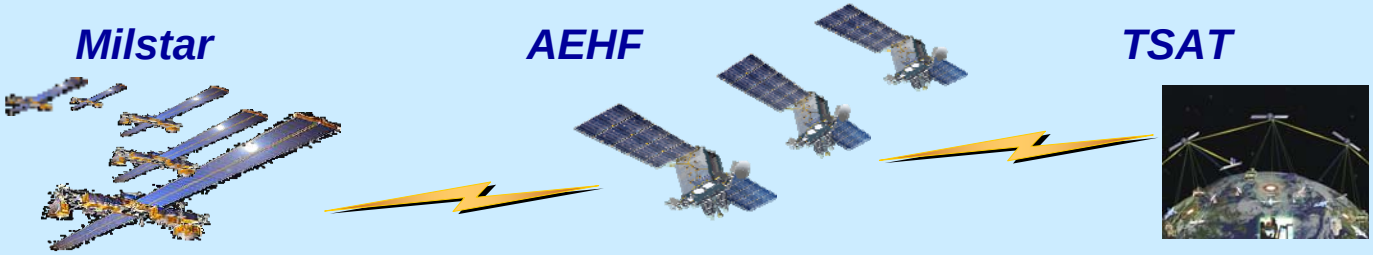
System Overview



AEHF Space Segment (3 Space Vehicles)

- Space Vehicle
  - System Timing
  - Autonomous Fault Detection and Correction
  - Jamming/Nuclear Protection
- Payload
  - Communication and Routing
  - Antenna Coverage/ Comm Capacity

Baseband

- Direct I/F to User
- User Interoperability
- End-to-End Services

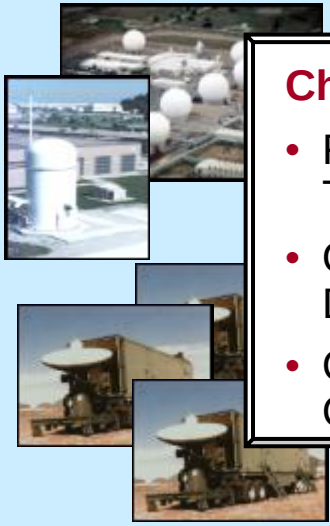
Terminals

- AEHF and Milstar
- International Partners
- User Comm Services
- User Resource Control

Mission Control Segment

- Apportionment Planning
- Sustainment
- Terminal Control
- Command and Control
- Training and Simulation
- Over-the-Air Rekey
- Ground Mobiles

AEHF MCS Mission Operations (MOPS)



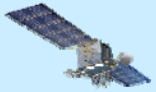
Characteristics

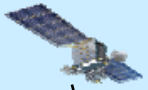
- Function: Command & Control, Telemetry, etc.)
- Object Oriented / Database Driven Design
- OO, Unix, C++, FORTRAN, SCL, Oracle, SQL

Test Program Description

- Modified waterfall
- Incremental Development
- Test Approach
  - Element test – req'ts based
  - MCS test – scenario based

Milstar





SDR/ SRR | Sys and Seg PDR | CY03 | CY04 | CY05 | CY06 | CY07 | CY08 | CY09 | CY10 | O&M

1 | 2 | 3 | 4 | 5 | 7

EPDR | MCS CDR

Inc 1 –Infrastructure Envt Completed Early

Increment 2 – Milstar Reuse

Increment 3 – LDR/MDR Apportionment

Increment 4 – LDR/MDR Command and Control

Increment 5 – XDR Command and Control

Increment 7 – Deferred Functionality

Factory Delivery

Field Deployed

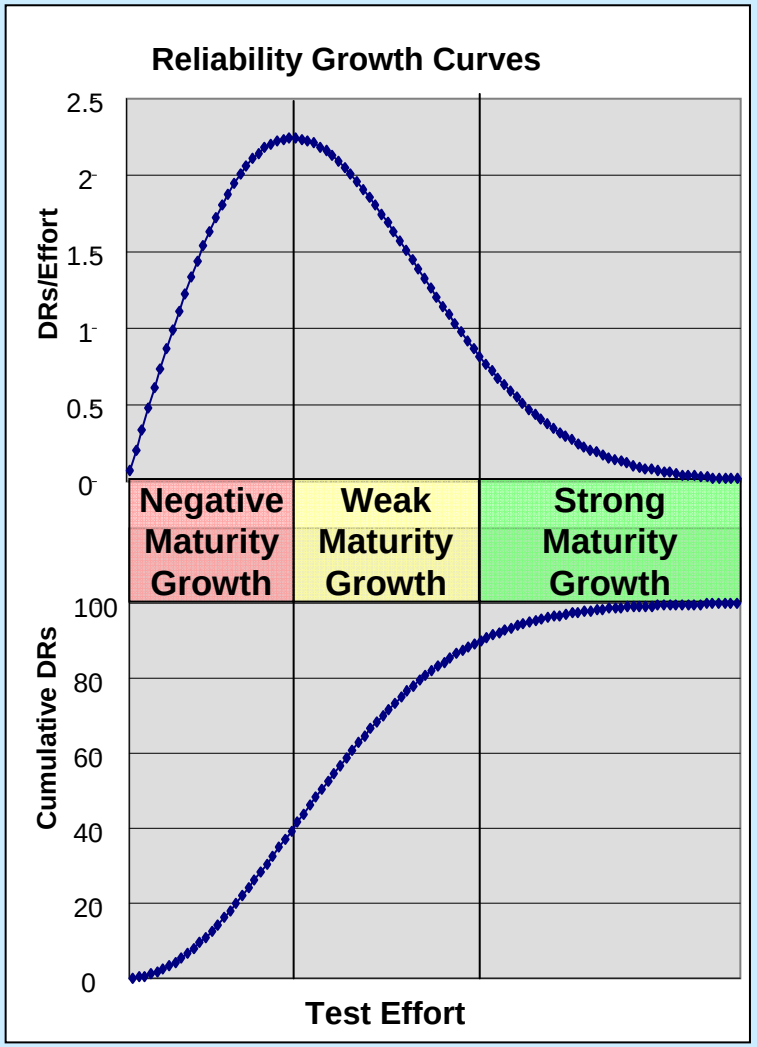
"Photos reprinted courtesy of the United States Department of Defense."

Introduction

- This brief provides results of our work to develop accurate and practical software defect density estimates using Weibull and Yamada-S Reliability Growth Models (RGM)
- Significant findings include:
  - Analysis of RGM curves developed with DR data in the “calendar-domain” can lead to inaccurate (and optimistic) estimates of total DRs in the code. The contributions of test effort on DR detection rates must be understood.
  - Aggregation of data (components, priority levels, etc.) from populations with dissimilar maturity characteristics degrades accuracy of estimates.
  - RGM results can provide useful information to software testing and release decisions

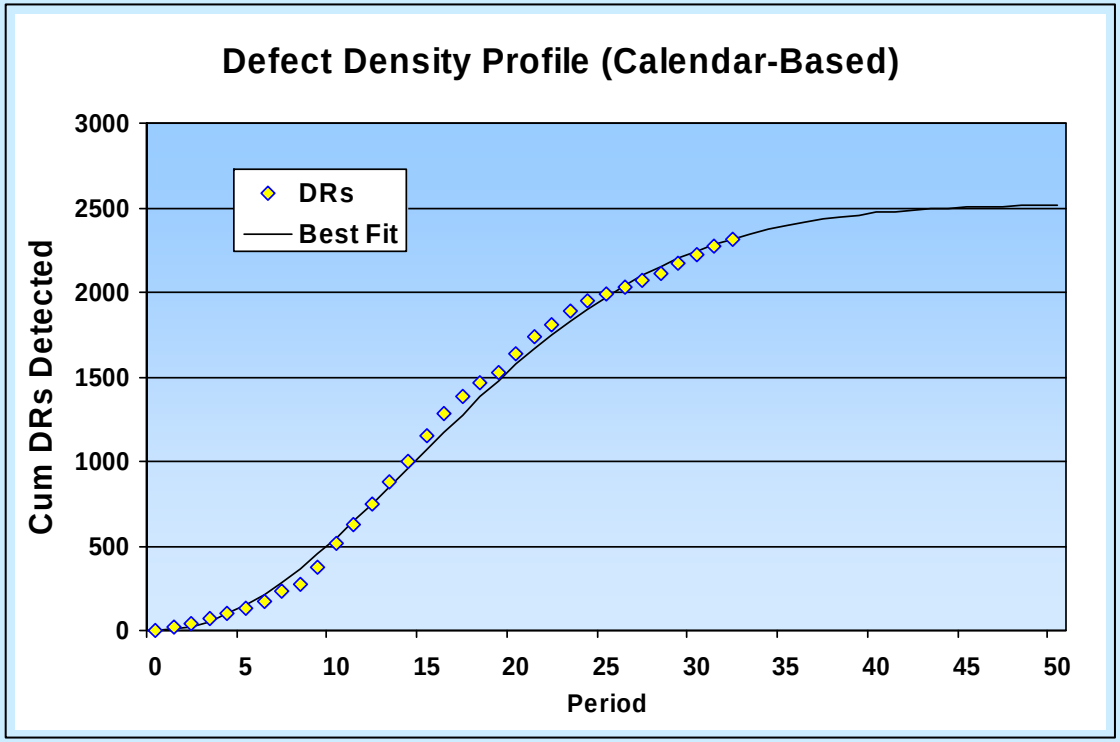
What are Reliability Growth Models (RGM)

- As we progress through the software test program, defect detection becomes increasingly more difficult
- RGMs are families of mathematical functions (Weibull, NHPP, etc.) that model the detection rate of software DRs during development (and operations)
- RGM analysis can be used to predict future detection rates and DR density once the code begins to demonstrate reliability growth
- RGMs are robust, although the DR data must still satisfy a number of assumptions



Analysis of Calendar-Based DR Detection Rates

- Calendar-based models assume a constant test effort across all periods (hours, days, weeks, etc.)
- RGM analysis of MOPS DRs show strong reliability growth with 93% of total estimated DRs found to date



What is driving the drop in DR detection rates?

Analysis of Calendar-Based DR Detection Rates

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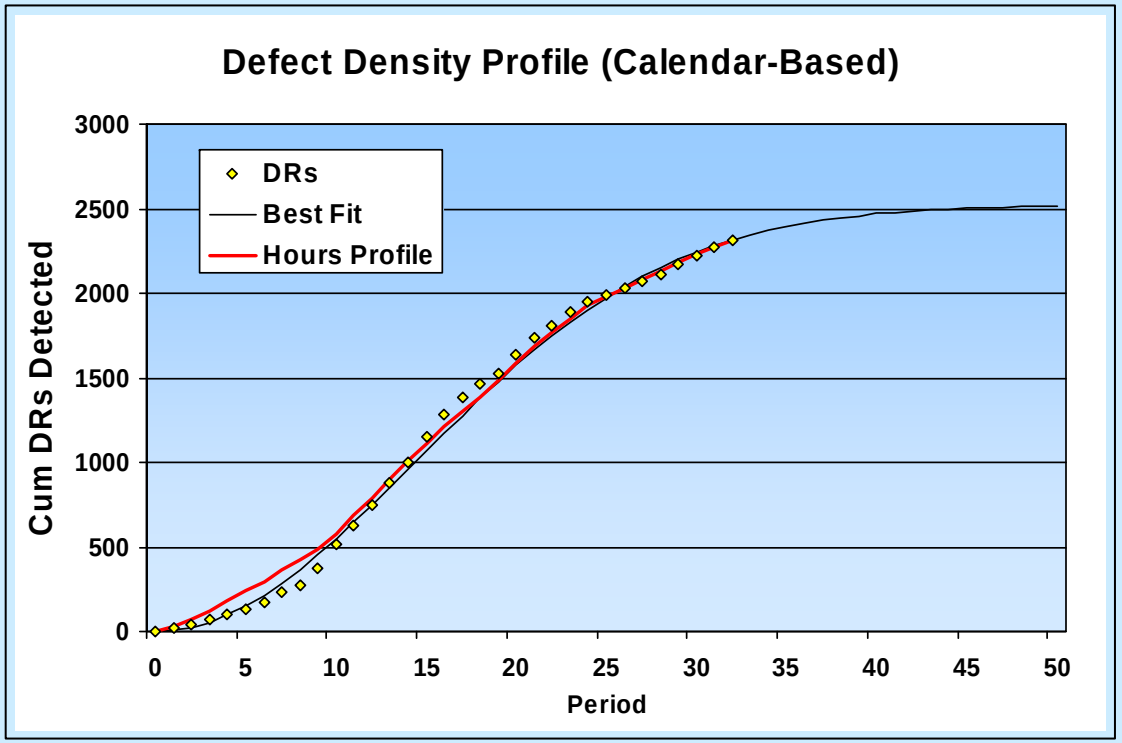
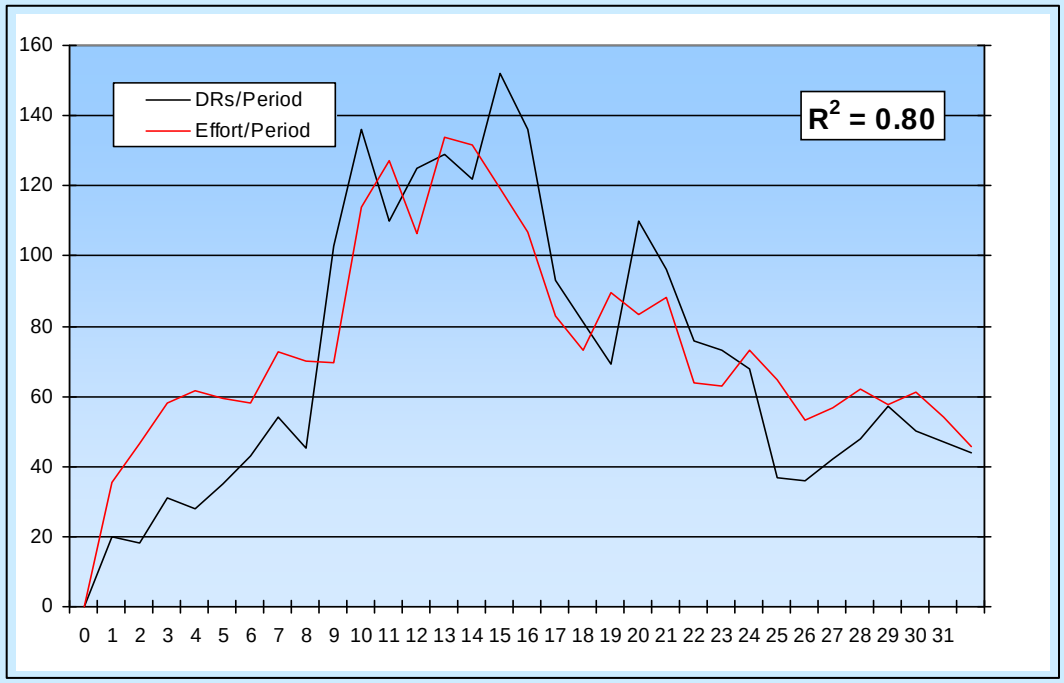


- Hours profile shows strong correlation between effort and DRs

Test effort, not reliability growth, is driving DR detection rates

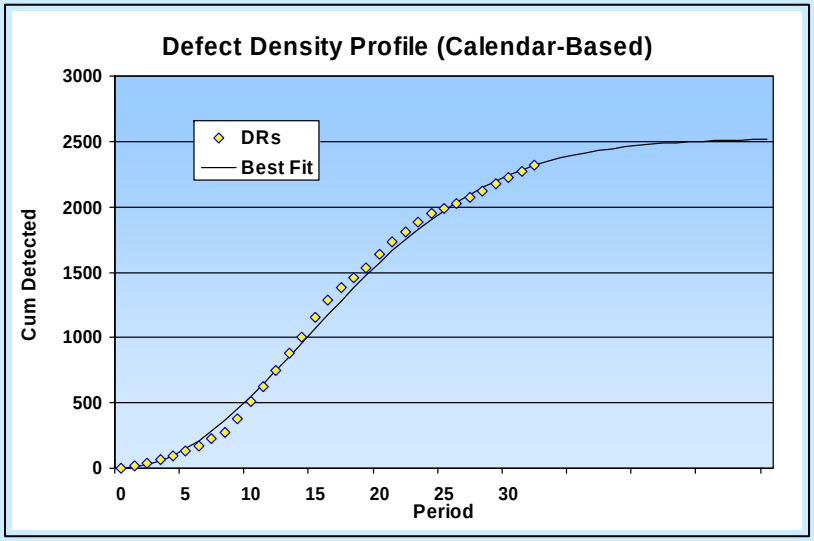
Analysis of Calendar-Based DR Detection Rates

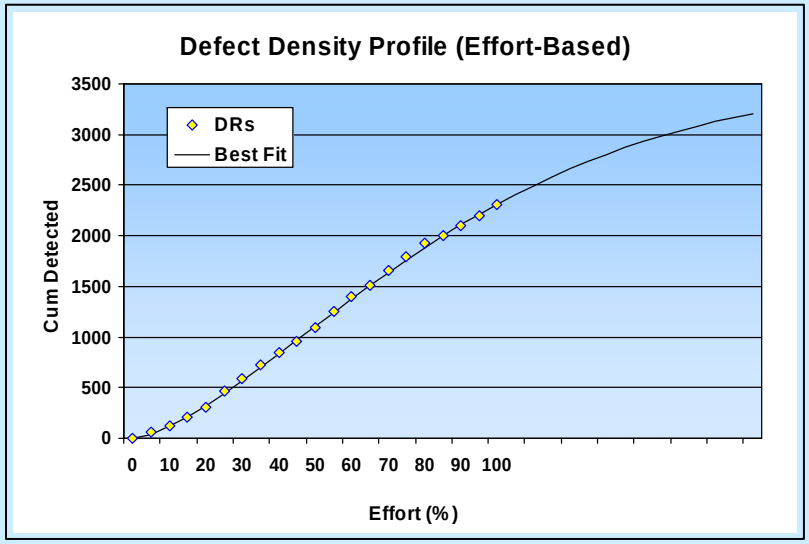
- Test hours alone explains 80% of the change in DR detection rates
- Data demonstrates a strong correlation between test effort and DR detections
- Reliability growth is a minor contributor to changes in MOPS DR detection rates



Calendar-Based approach is highly susceptible to changes in effort

Analysis of Effort-Based DR Detection Rates





Comparison between Calendar- and Effort-Based DDPs:

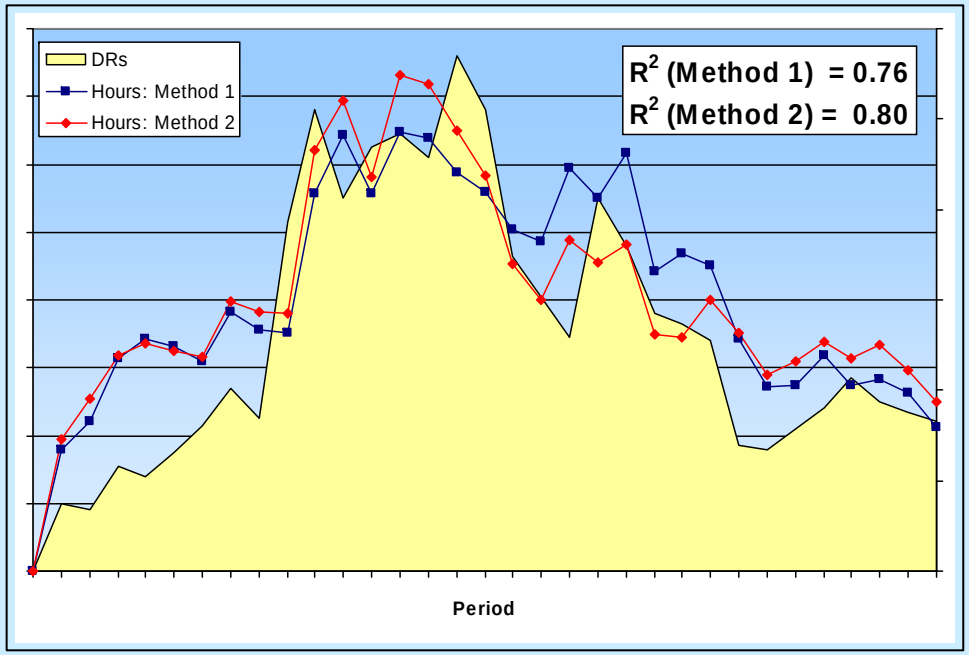
- Calendar-based analysis
  - With 93% of total estimated DRs found the software is in the strong reliability region of its S-curves and ready for fielding
- Effort-based analysis
  - With 65% of total estimated DRs found the software is in the weak reliability region of its S-curves and not ready for fielding

Calendar-Based estimates can yield unreliable results.

Test Effort Profile Estimates

Our goal is to develop a profile that depicts the relative on-console test effort from labor data which includes many other test-related activities.

- Method 1: Total hours across all test accounts and activities
  - Pros: Easiest metric to collect and implement
  - Cons: Assumes all test stages have equal efficiency
- Method 2: Length of test procedures and hours charged to test accounts
  - Pros: More accurate test effort profile: introduces test phase efficiency coefficients
  - Con: More difficult to implement



Both methods yield adequate test profiles

Process Improvements

- Established a set of Software Maturity metrics to track the progress of the software through the development / test lifecycle.
  - Observations from the RGMs along with other key metrics provide great insight into the reliability and readiness of the software.
  - Utilizing RGMs based on test effort provides a more accurate depiction of software reliability
- Developed additional metrics including software change frequency metrics which have identified specific areas requiring additional attention.
- Improved our processes to include a forum for the analysis and discussion of software reliability.
- Developing software maturity goals which can be eventually used to help answer the age-old questions “is the software ready to ship and if not, when will it be ready?”