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Reliability Growth of Mobile Gun System during PVT

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Agenda

- **What is MGS**
- **Success Factors of MGS PVT**
  - Program Management – Integrated Team
  - System Engineering and Reliability Attainment
  - Reliability Data Analysis – RGA
    - FDSC – Failure Definition Scoring Criteria
    - Failure Categories
    - Inherent vs. Induced Reliability
    - Mission Profile and Life Variable
    - Data Grouping and Modeling
    - Instantaneous vs. Cumulative Reliability
- **MGS Lesson Learned - DFR**

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Stryker Family of Vehicles

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Mobile Gun System – The Bunker Buster

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BLUF – Key Factors for Successful Reliability Growth Program

- **Program Management – Integrated Team**
  - The systems, tools, and practices now in place between the US Government and General Dynamics Land Systems allowed the system's reliability to grow (repeatable process)
  - Reliability growth requires commitments from Material Developer Team, Combat Developer, and Independent Test and Evaluation Communities (requirements, test, data, methodology, tools)
- **System Engineering – Reliability Backbone**
  - Integrates All Reliability Tasks
  - Redirects Tasks Toward a Single Objective
  - Crosses Boundaries Affecting Operational Reliability
  - Provides Program Manager Authority, Funding, and Focus on Engineering, Processes, Documentation, Training, Manufacturing, and Testing for Reliability
- **Reliability Data Analysis – Reliability Assessment**
  - FDSC – Failure Definition Scoring Criteria
  - Failure Categories
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MGS Program Management

Plan

- Phase I - Conduct an Additional Reliability Test (ART)
  - Validate effectiveness of 216 PQT and Post-PQT corrective actions
- Phase II - Implement changes to Government and GDLS Systems Engineering Processes
  - Management and process changes
- Phase III - Redesign of Sub-System components and integration

Tests

- Additional Reliability Testing (DEC 2004 – MAR 2005)
  - 2 vehicles
  - Pre-ART – XXX rounds & X00 miles
  - ART – XXX rounds & X,000 miles
  - Reliability Point Estimate XX MRBSA
- Reliability Growth Test (JUL-AUG 2005)
  - 2 Vehicles
  - XXX rounds
  - X,000 miles
  - Reliability Point Estimate XX MRBSA
- Production Verification Testing (APR 2006 - DEC 2007)
  - 3 Vehicles
  - XXXX rounds
  - XX,000 miles
  - On-going – Current estimate XXX MRBSA

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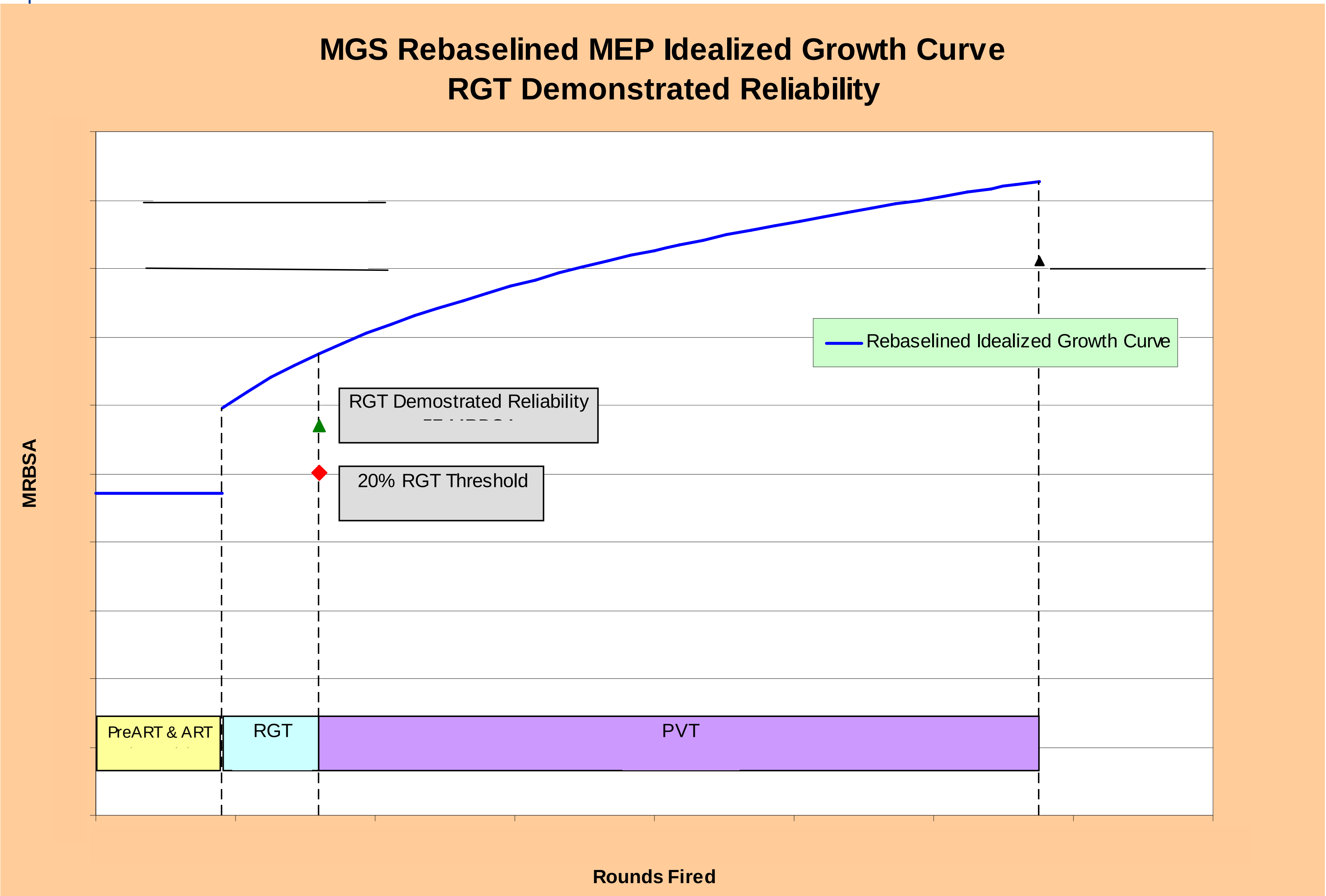
MGS Idealized Growth Curve



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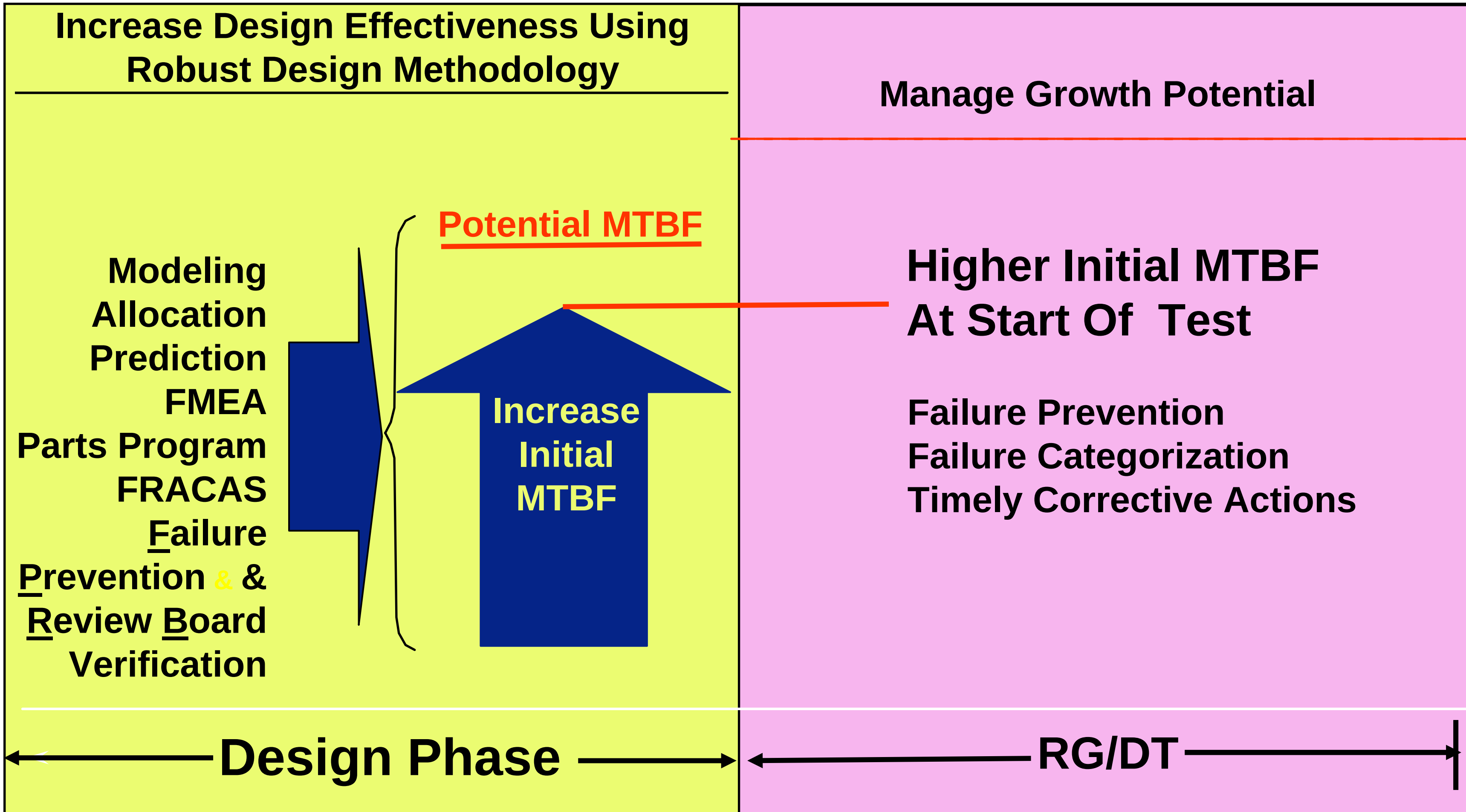
MGS - Systems Engineering Approach

- Integrates All Reliability Tasks
- Redirects Tasks Toward a Single Objective
- Crosses Boundaries Affecting Operational Reliability
- Provides Program Manager Authority, Funding, and Focus on Engineering, Processes, Documentation, Training, Manufacturing, and Testing for Reliability
- Approach Provides Metrics that can be Measured

SE Approach to Reliability



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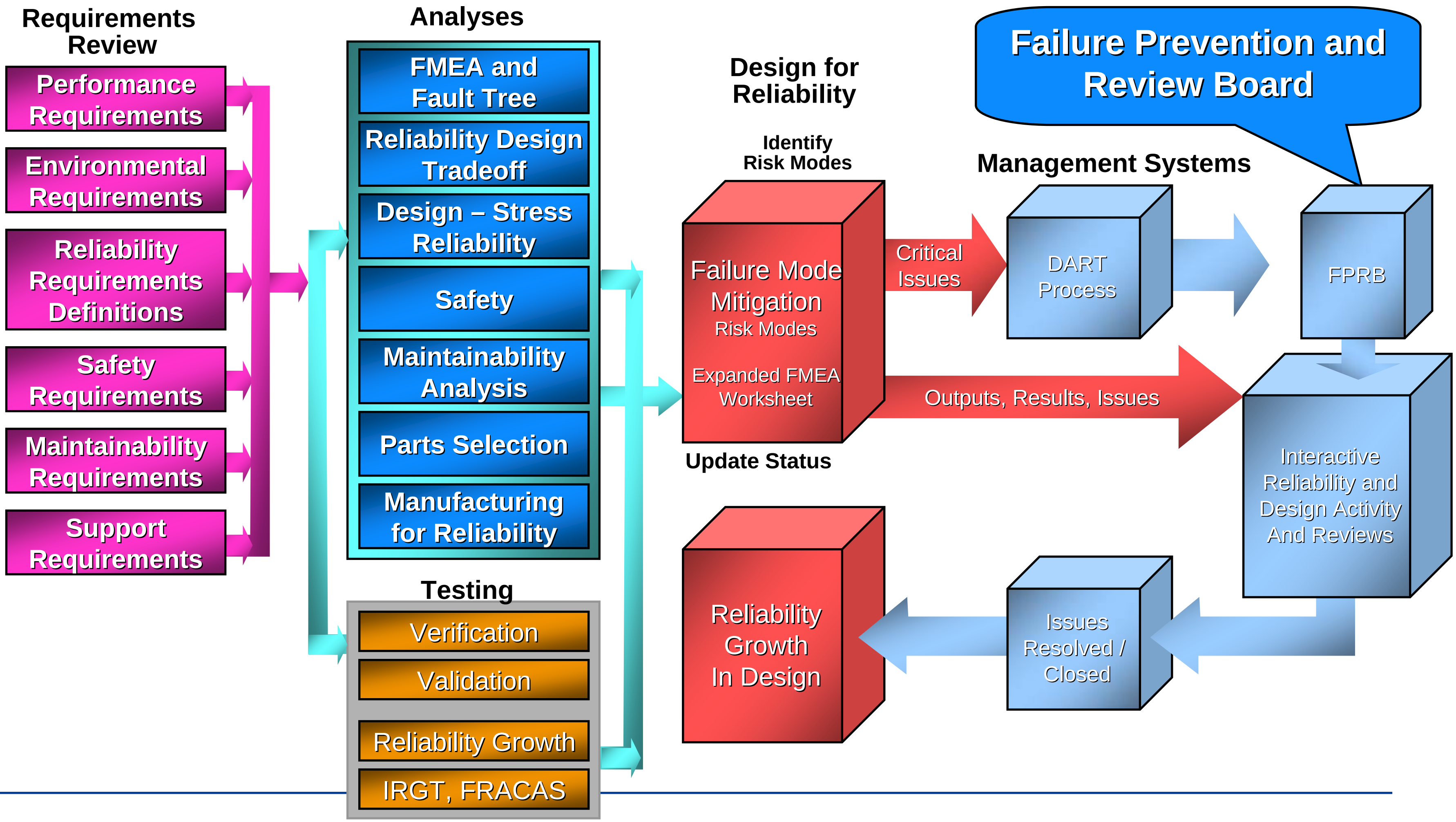
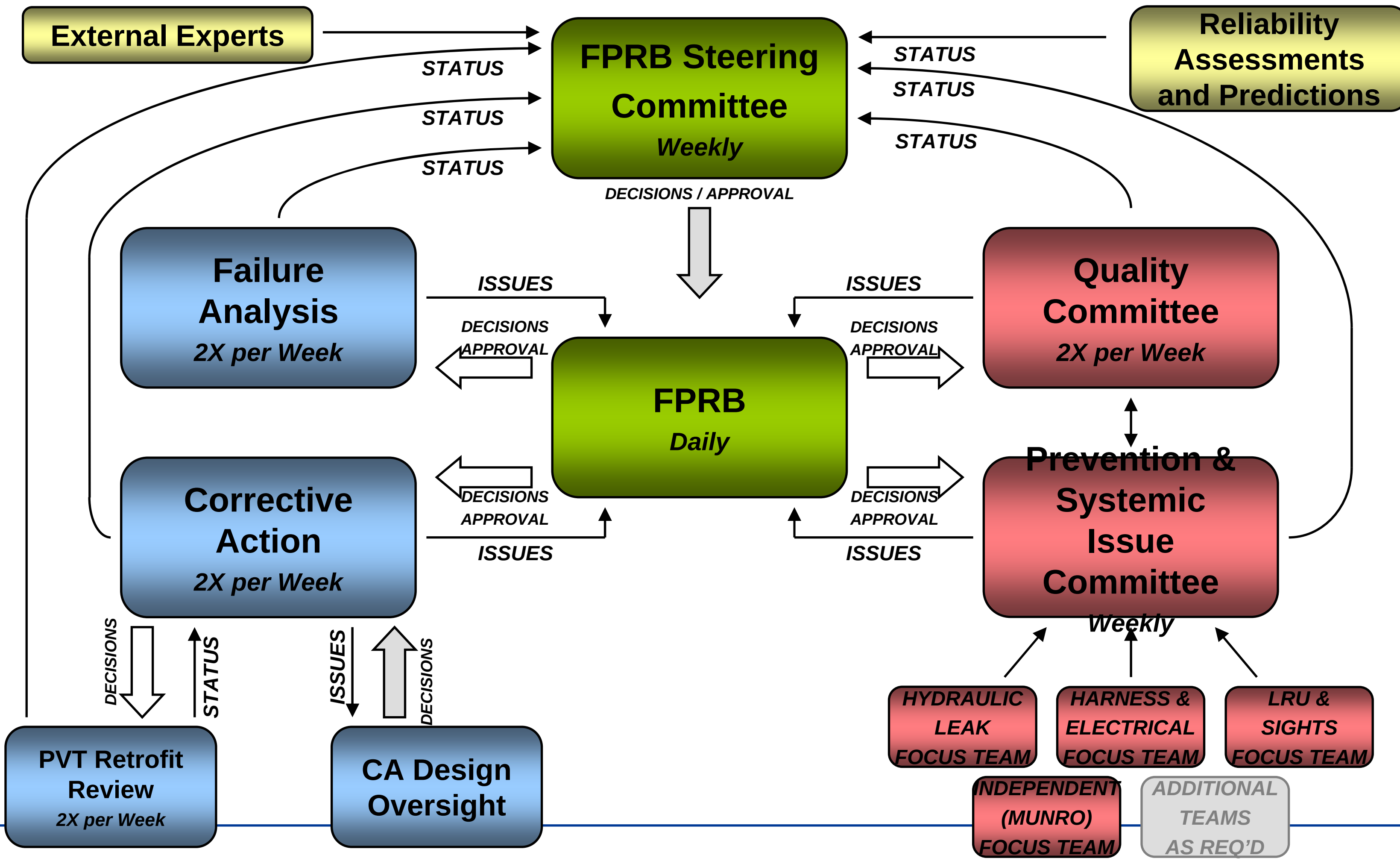
Design for Reliability Management Focuses on Failure Prevention



Stryker – Mobile Gun System
Failure Prevention and Resolution Implementation



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Reliability Data Analysis

- Proper Reliability Assessment is a key for the program success at PVT
- Reliability Assessment must be discussed up front and consensus should be reached on:
  - FDSC – Failure Definition Scoring Criteria
  - Failure Categories
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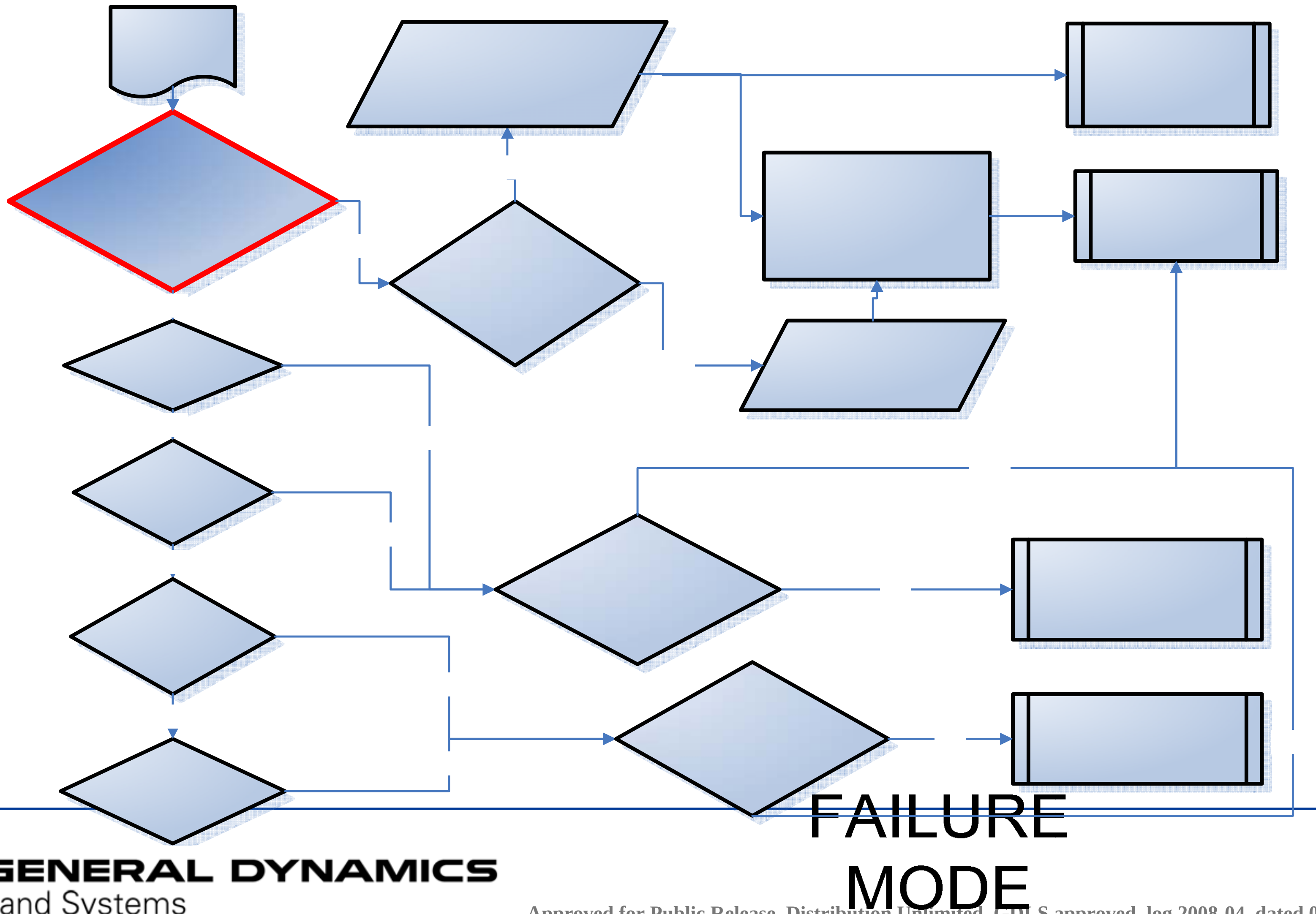
FDSC – Failure Definition Scoring Criteria

- FDSC is Contractual Document that defines
  - Failure/non-Failure Event
  - Test related Event
  - Severity of Failure as it relates to the Mission
  - Cause of the Failure
- FDSC is prepared as required by Army Regulation 70-1, Army Acquisition Policy.
- FDSC is being used through out the test for Scoring purposes, hence it is a major document for Reliability Assessment

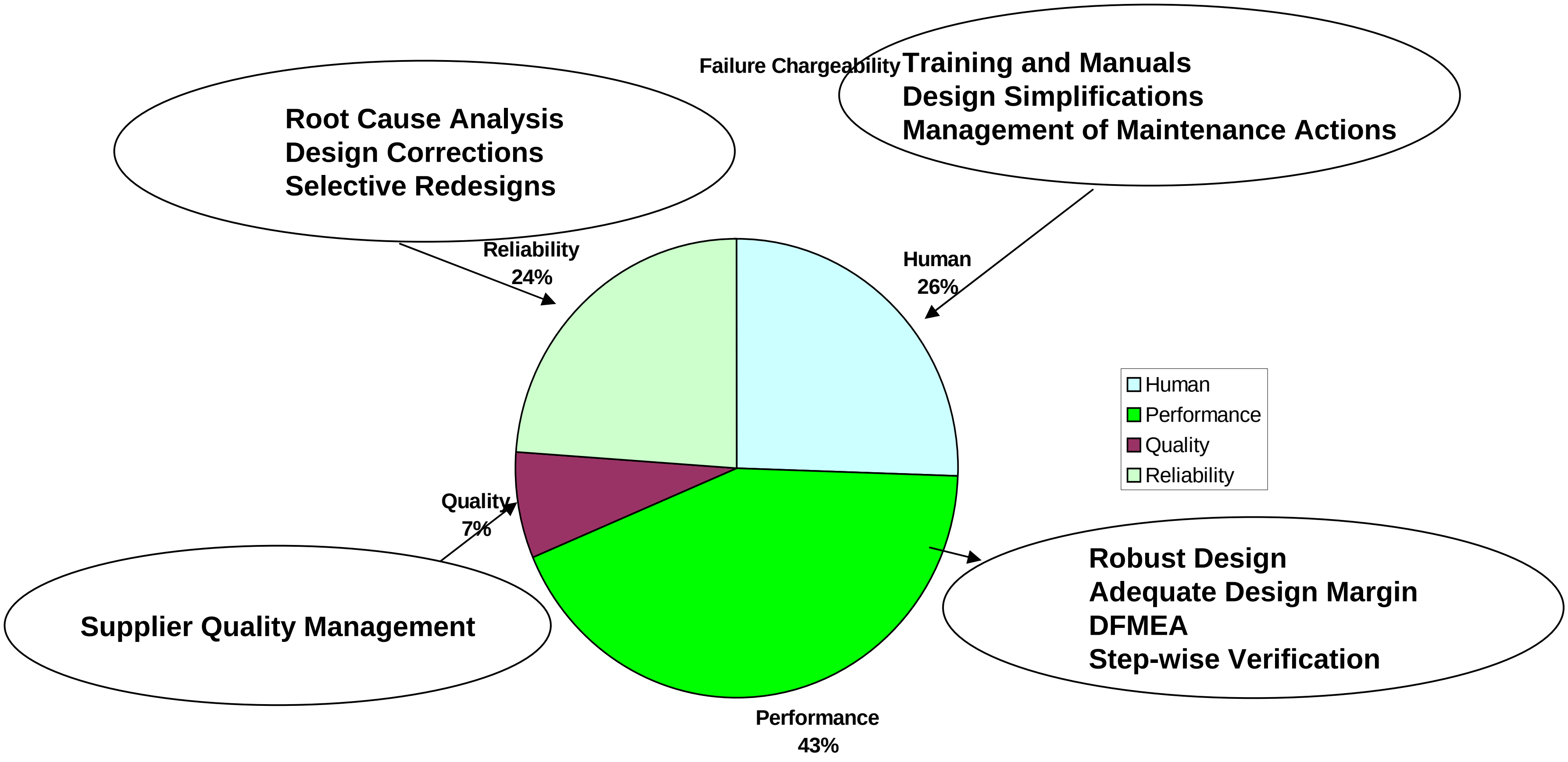
Failure Categories

- Performance FM – FM is repeatable with 100% probability of failure for the given procedure/conditions. (Example: TDS overheating)
- Software FM – same as above, but software related.
- Quality FM – happens when vehicle is not built/maintained/operated as designed and is not repeatable after fixing (probability of failure =0%). Can be broken down into Initial Quality, Maintenance, Operator error, etc. (Example: Improperly installed harness, turret lock bended, etc.)
- Potential Reliability FM – happens when vehicle was built/maintained/operated as designed/intended; probability of failure is greater than 0% and less than 100%; usually happens due to wear out, environment, insufficient design, manufacturing variability, etc.

Failure Mode Categorization Process
Inherent vs. Induced Failure



Categorize Failures and take Relevant Management Actions



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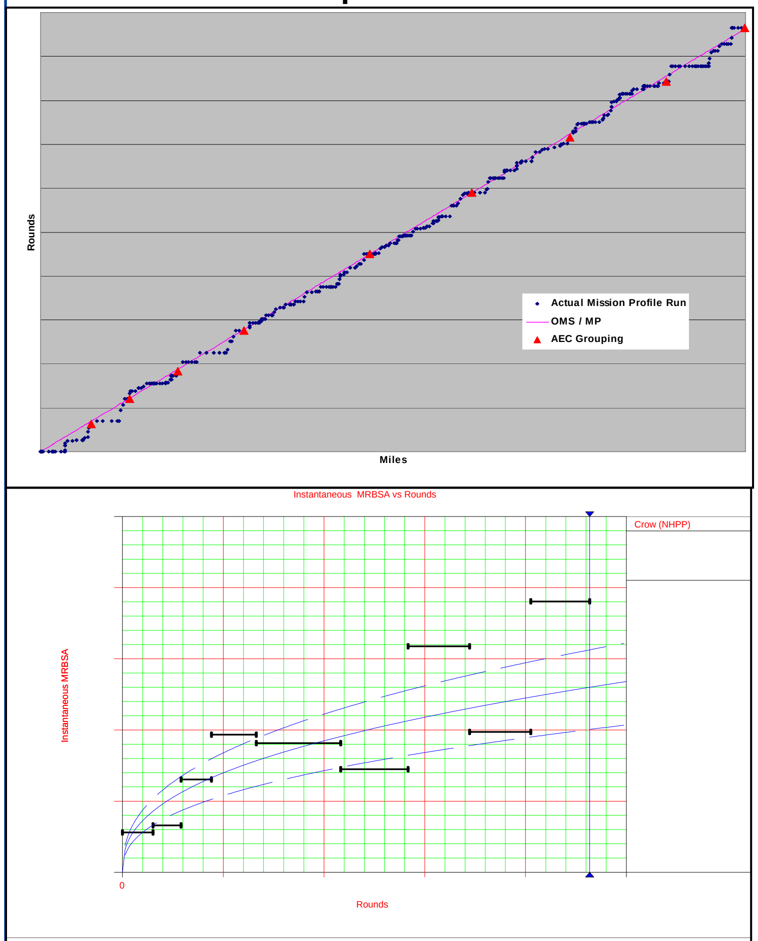
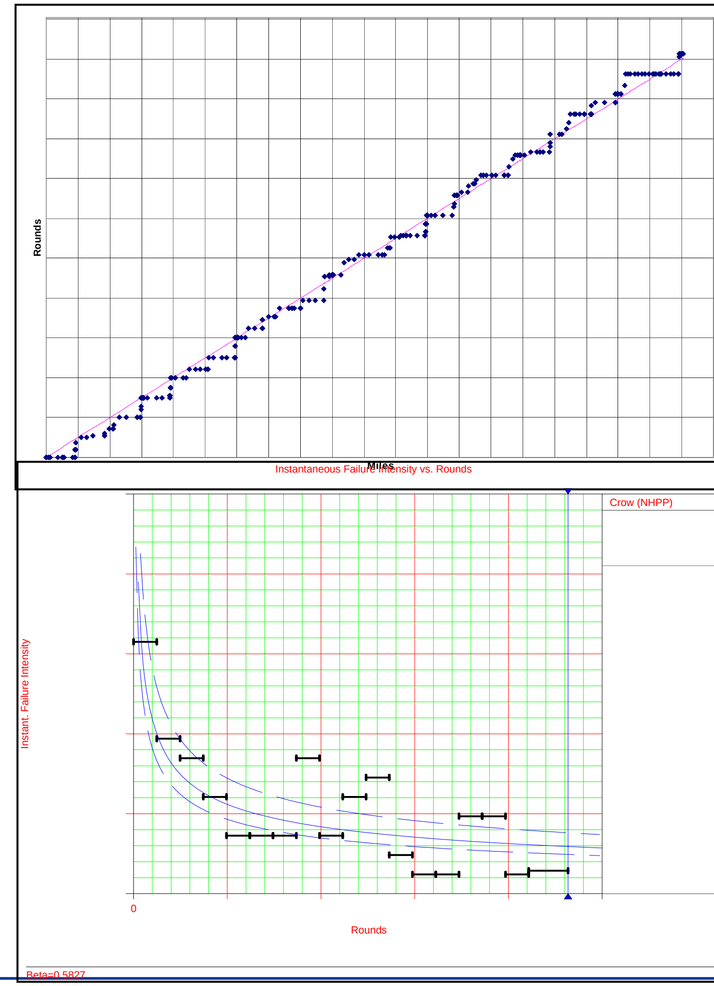
Data Grouping

Known Equivalent Time



Unknown Equivalent Time



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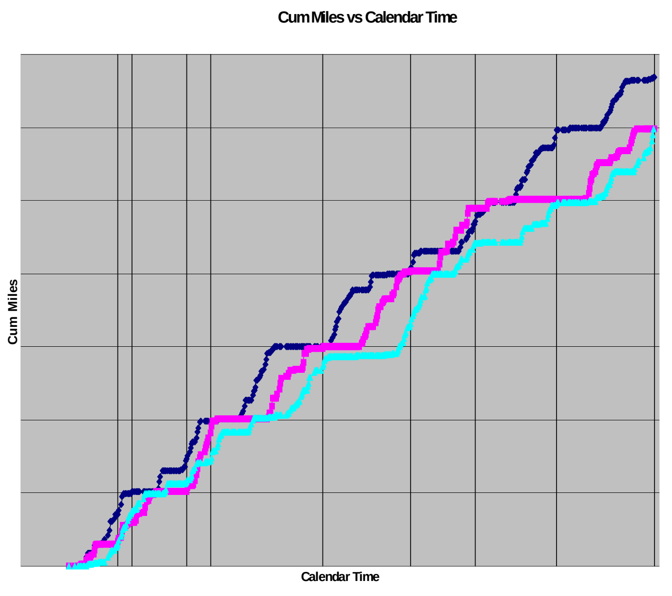
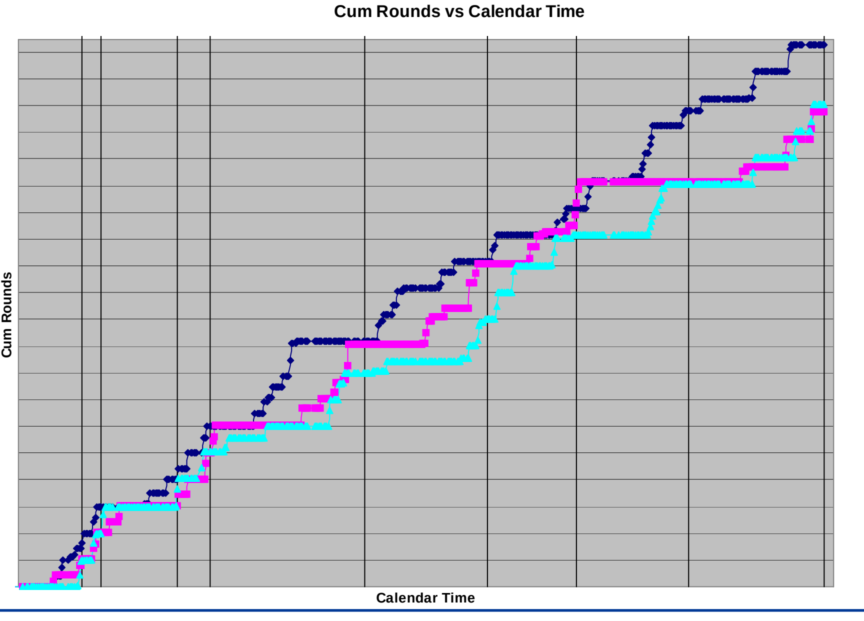
Rounds and Miles Accumulation per Vehicle vs. Calendar Time



UET model takes into account any discrepancies between different vehicles following through the test in calendar time

KET Model can be useful in the beginning of the test when vehicles have not accumulated enough mileage and rounds.



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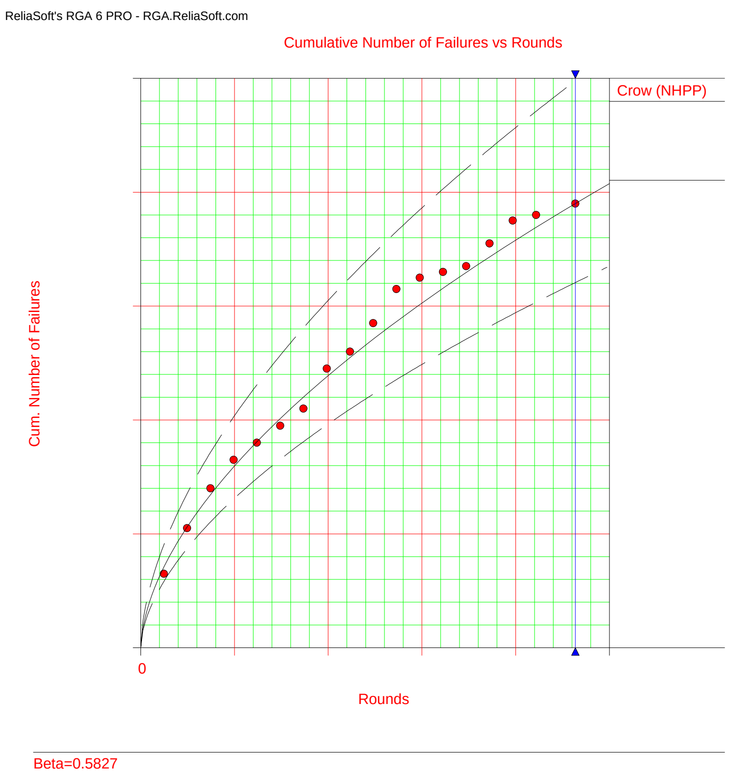
Crow/AMSAA Model



Cum Number of Failures

$$\boxed{E(N) = \lambda \cdot T^{\beta}}$$

Cum Failure Rate

$$\boxed{r_c = \frac{E(N)}{T} = \lambda \cdot T^{\beta-1}}$$

Cum MTBF

$$\boxed{MTBF_c = (r_c)^{-1} = \left(\lambda \cdot T^{\beta-1}\right)^{-1}}$$

Inst Failure Rate

$$\boxed{r_i = \frac{d(E(N))}{dt} = \frac{d\left(\lambda \cdot t^{\beta}\right)}{dt} = \lambda \cdot \beta \cdot t^{\beta-1}}$$

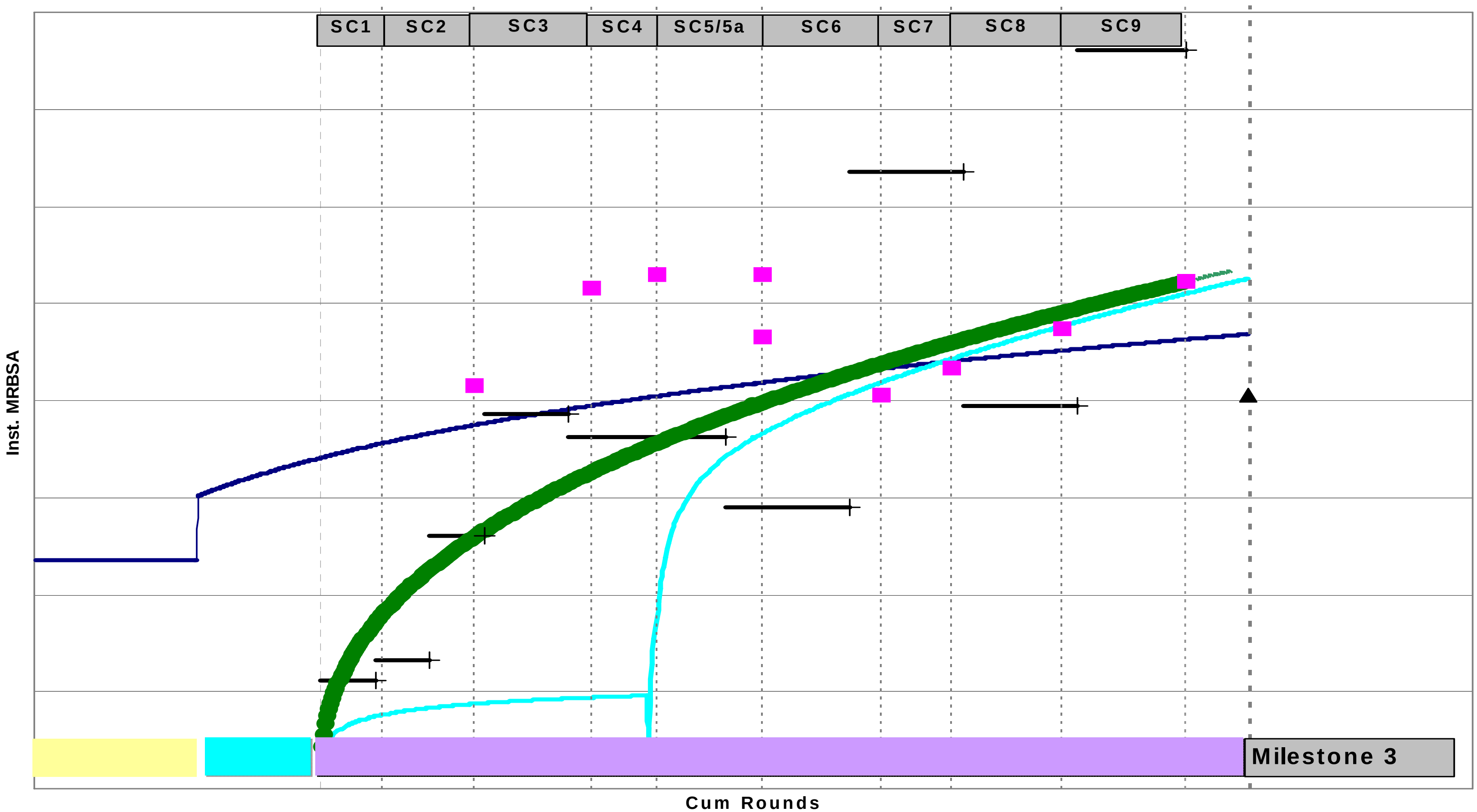
Inst MTBF

$$\boxed{MTBF_i = (r_i)^{-1} = \left(\lambda \cdot \beta \cdot T^{\beta-1}\right)^{-1}}$$

Cumulative vs. Instantaneous Reliability

- Reliability growth on the Development test is the result of Corrective Actions.
- Estimating Reliability of the product by taking the Cumulative reliability (total number of failures / total time on the test) does not take into account the growth on the test.

Idealized Growth Curve and Observed Parametric Curve for Demonstrated Instantaneous MRBSA



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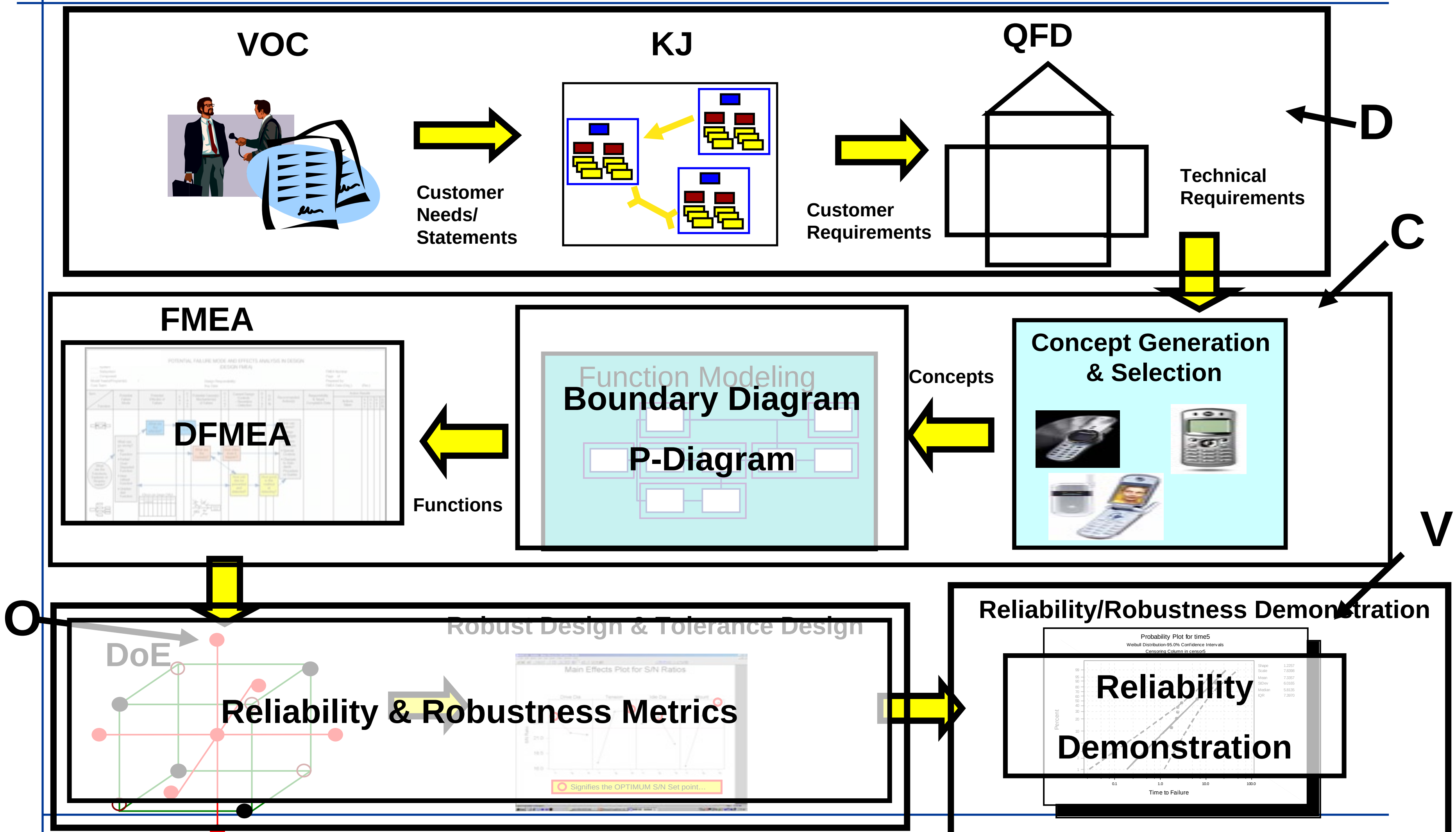
DFR Process Elements

- **Boundary Diagram / System Block Diagram**
- Interface matrix
- **P-Diagram**
- **DFMEA**
- Reliability & Robustness Metrics
- **DVP&R**
- **Reliability Demonstration Metrics**

DFSS (DCOV) Flow of Analysis & Tools



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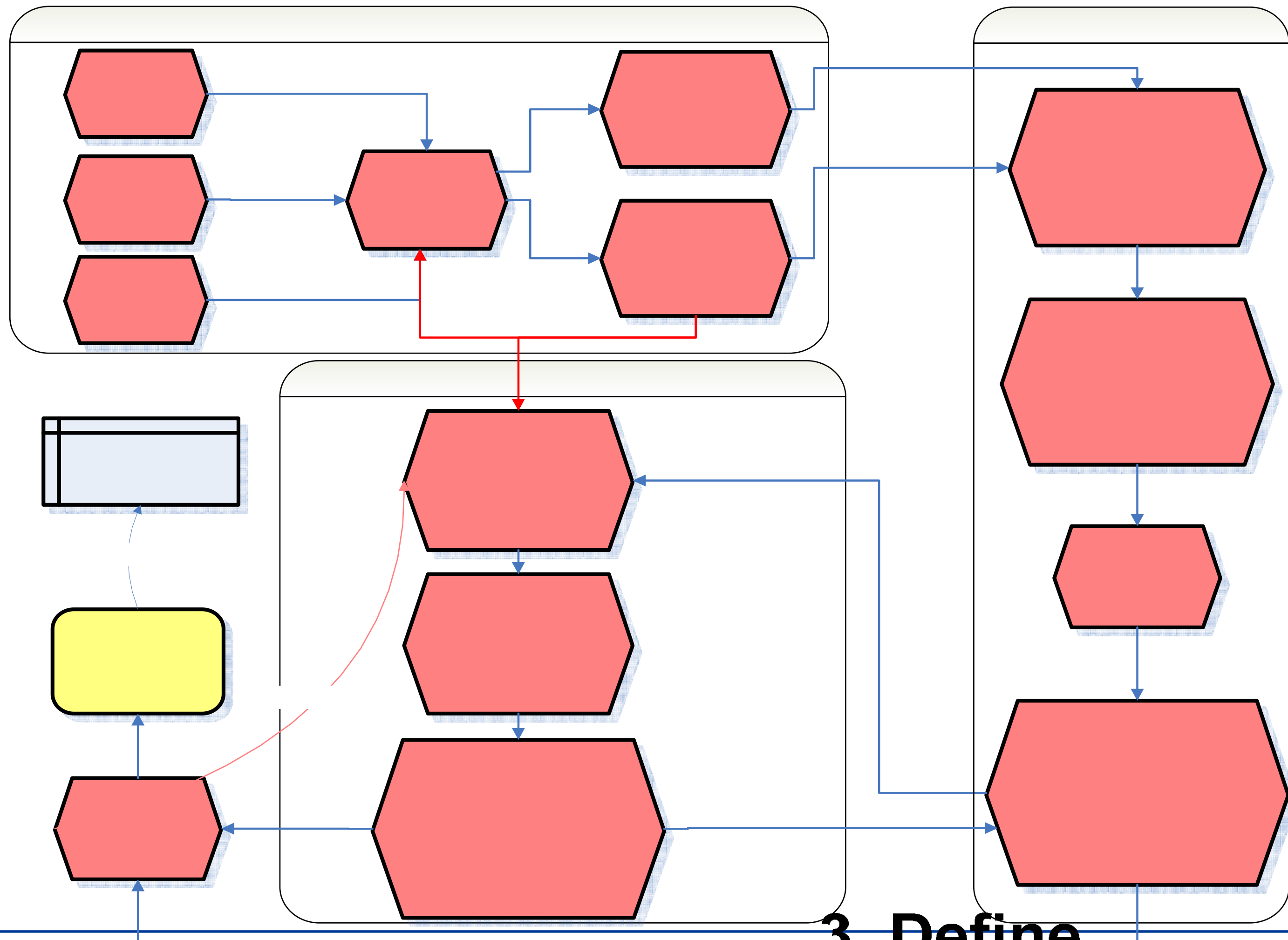
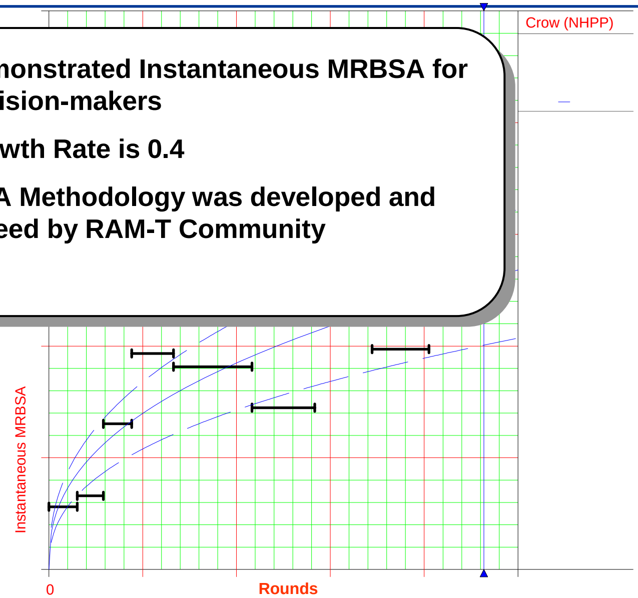
Design For Reliability Map

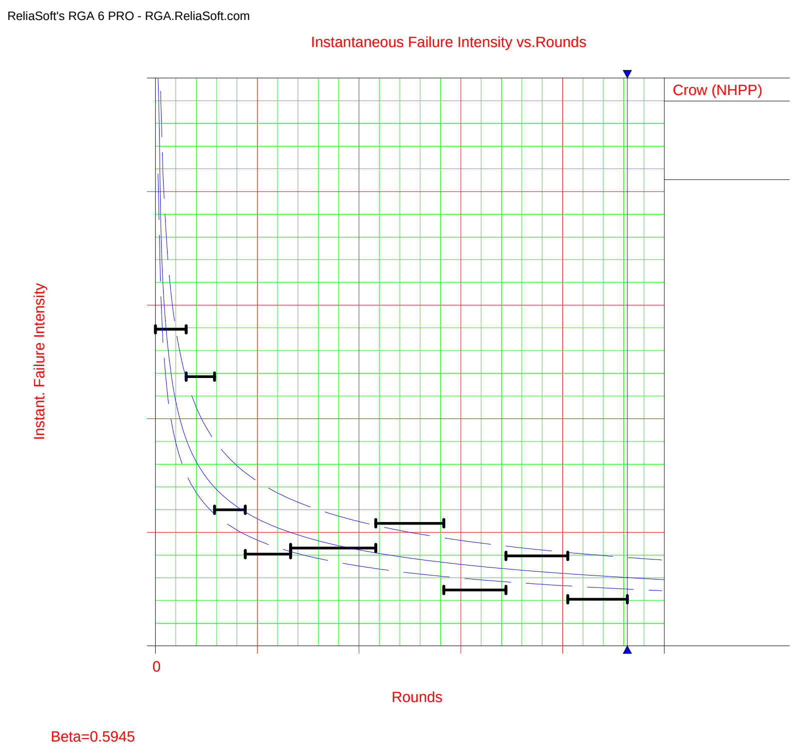


MIL-HDBK-189 RGA Method
MGS MEP PVT Instantaneous MRBSA

- **Demonstrated Instantaneous MRBSA for decision-makers**
- **Growth Rate is 0.4**
- **RGA Methodology was developed and agreed by RAM-T Community**



- **Failure Rate continues to decrease, thus demonstrating substantial reliability growth in PVT**
- **Sustained decrease of MGS Failure Rate suggests infant mortality region is passed and design is maturing**



<u>Continuing the effort to ensure MGS reliability growth</u>

- **Systems Engineering Process continues to be worked "24/7"**
- **GDLS Senior Leadership briefed on a daily basis**
- **Focus on implementation of Corrective actions on both the Test Vehicles and the Fielded vehicles**
- **GDLS teams at our vendors to work failure analysis and ensure MGS gets their top priority**
- **Outside experts on reliability and quality regularly review our processes in engineering and Manufacturing so we keep getting better**

Keys to Success

- Program Management forms Integrated Team (Material Developers, Tester/Evaluators, User) that has clear priority and focus on Reliability with clear understanding of Evaluation Criteria and Test Methods up front.
- System Engineering assembles Reliability tools into Disciplined processes and Working Organizations
- Reliability Assessment is reached through in-depth analysis and consensus between all involved parties

Program Management + System Engineering + Reliability = Success

Questions and Discussion

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