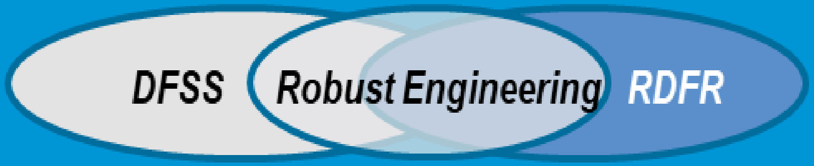
Reliability Program and

Design for Reliability Best Practices



ASQ Reliability Forum

Dr. Matthew Hu
Date: December 1, 2020
Phone: 281-299-4230
Website: www.rstiglobals.com

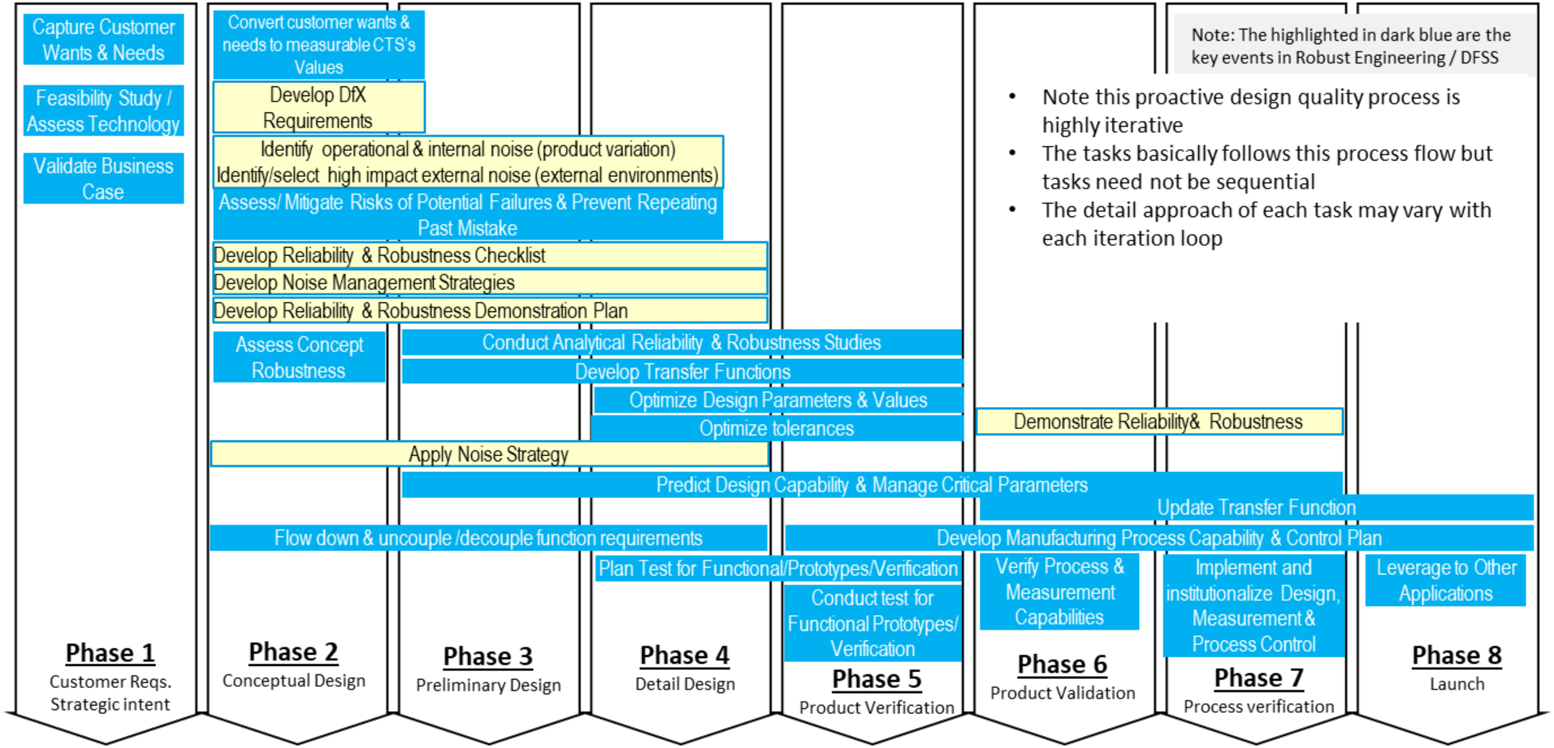
Reliability Program Initiatives and Launch Points

Initiatives	Launch Points & ROI		Leader / Champion	Skills, Training & Tools	Processes
	Warranty		Director of Quality	FRACAS, Weibull, Life Data Analysis	RDfR/PHM /IoT
	Test Development		Director of test lab	AB Test, Weibull, Robustness, Degradation, Field, HALT, ALT,	
High ROI	Product Development and R&D		VP / Director of Eng	FD, P-Diagram, BD, RBD, Modelling, AB Test, Simulation, Reliability Growth, Optimization, Weibull, Robustness, Degradation, Field, HALT, ALT, Stress-strength, life-cycle cost	DFSS / RDfR / PHM/ APQP/ IoT
	Plant / Manufacturing	Maintenance	Maintenance Mgr	Reliability and Maintainability Analysis for Repairable Systems, Equipment, life-cycle cost.	RDfR/PHM/IoT
		Operation	CI/Operation Director	Risk assessment, clear knowledge, Process Capability, SPC, Weibull, BIT, life-cycle cost	RDfR/PHM / IoT

DFSS: Design for Six Sigma
RDfR: Robust Design for Reliability
PHM: Prognostic Health Management
APQP: Advanced Product Quality Planning

Matthew Hu; 281-299-4230; mhu@rstiglobals.com

DfR Alignment and Implementation Scorecard



Matthew Hu; 281-299-4230; mhu@rstiglobals.com

Matthew Hu; 281-299-4230; mhu1529@gmail.com

DfR Best Practices

Successful DfR requires the integration of product design and process planning into a cohesive, interactive activity known as concurrent engineering.

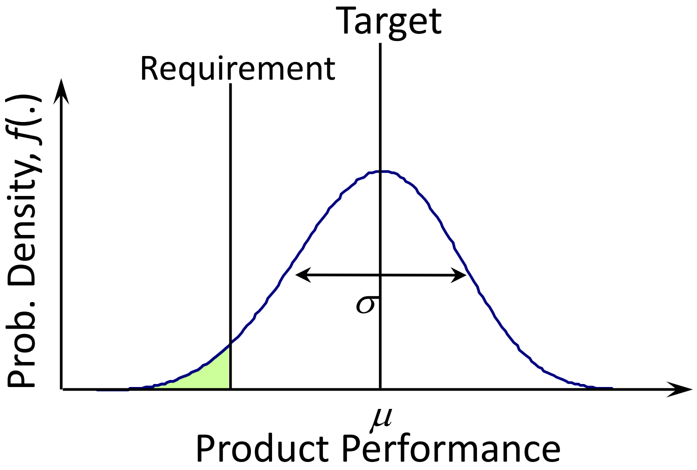
Some DfR best practices include following but not limited to:

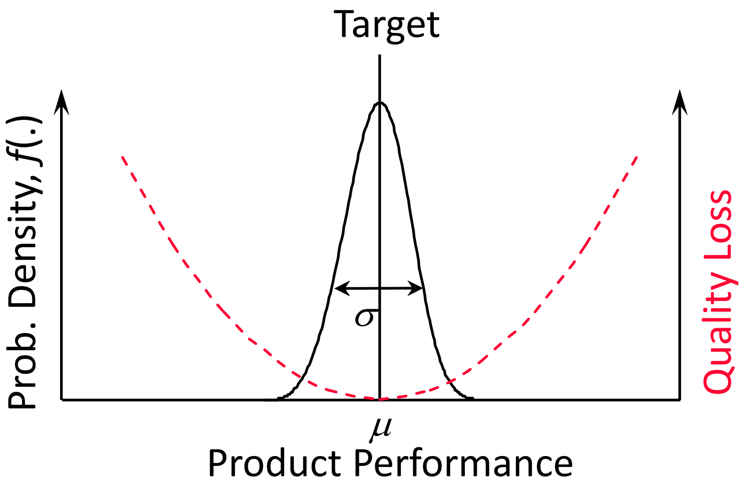
- Adopt Robust Design for Reliability aligned with product development process (PDP).
    - Make design insensitive to uncontrollable user environment (e.g., piece-to-piece variation, aging, usage, external environment, interfaces and interactions)
    - Early development of robustness is key to proactive quality and reliability improvement
        - Capture, front load noise and manage noise
        - Gain control of your product performance
        - Optimize robustness – avoid all failure modes
    - Apply Robust design principles at early stages of product design to “forecast” problems

Matthew Hu; 281-299-4230; mhu@rstiglobals.com

Matthew Hu; 281-299-4230; mhu1529@gmail.com

Reliability and Robustness (An Engineering Measure of Reliability)





Reliability: *probability* of a product performing its intended function for a specified life under the operating conditions encountered.

Q: How do you know the f(.) when a design is new?

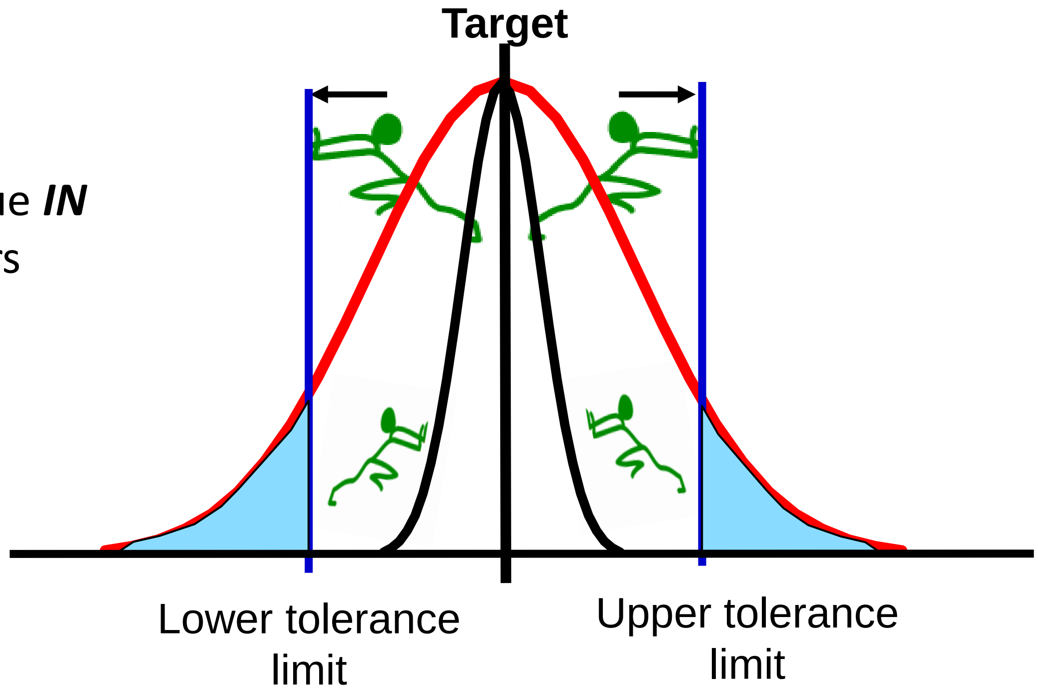
Computing probability of success requires knowledge of m, s, ***f*** **(.)**

Robustness: ability of a product to perform its intended function consistently in the presence of uncontrollable user environment (noise) during its intended life. In other words, the product is insensitive to noise.

Assessing robustness requires knowledge of m, s

Robustness Solves the Problem

Robustness - low variation of ideal performance around the target value ***IN SPITE OF*** the effects of Noise Factors (uncontrollable user environment)



Matthew Hu; 281-299-4230; mhu@rstiglobals.com

DfR Best Practices (Continued 1)

- Set reliability goals based on survivability. This is often bound by confidence levels, such as 95% reliability with a 90% confidence level over design life.
- Maximize engineering confidence using robust design principles in the presence of uncontrollable user environment and PoF instead of statistical sample size confidence.
- Avoid mean time to failure (MTTF) and mean time between failures (MTBF) because they do not measure reliability. Historically, MTBF has been calculated using the empirical prediction handbooks, which assume a constant failure rate that is not always correct.

Uncontrollable User Environment

Uncontrollable Environment	Caused by
Piece-to-piece variation	Production rate
Change over time	Exposure to repetitive demand
Customer usage and duty cycle	Conditions of use
External operating environment	Climatic & application conditions
Internal operating environment	Interfaces & interactions

Matthew Hu; 281-299-4230; mhu@rstiglobals.com

Matthew Hu; 281-299-4230; mhu1529@gmail.com

DfR Best Practices (Continued 2)

- Employ physics of failure (PoF) to acquire a deep understanding of how the desired lifetime and environment affect the design. This takes substantial effort, but there is valuable return in:
  - Determining average and realistic worst-case scenarios
  - Identifying all failure-inducing loads using HALT/ALT/HASS, Robustness Assessment and etc.
    - Temperature
    - Humidity
    - Corrosion
    - Power cycling
    - Thermal cycling
    - Electrical loads and noise
    - Mechanical bending
    - Random and harmonic vibration
    - Shock
    - Including all environments
    - Manufacturing
    - Transportation
    - Storage
    - Field and others

Keep dimensions loose at this stage. A large number of hardware mistakes are driven by arbitrary size constraints. An approach Product Development Process (PDP) aligned Reliability Scorecard for DfR implementation optimizes product reliability, development time and cost savings.

Matthew Hu; 281-299-4230; mhu@rstiglobals.com

Matthew Hu; 281-299-4230; mhu1529@gmail.com

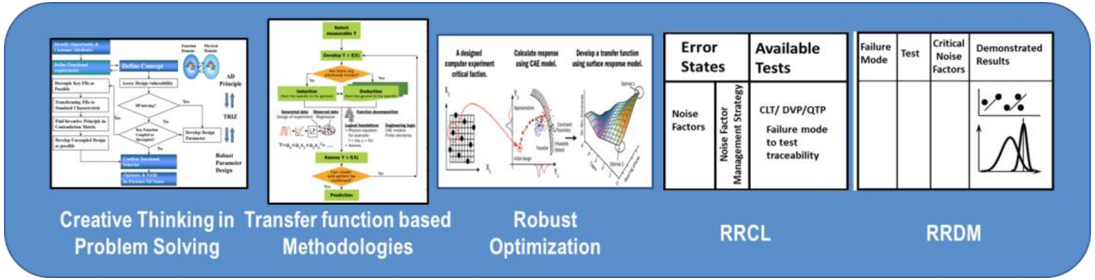
DfR Best Practices (Continued 3)

- Build a solid DfR team and provide with the right tools
- Understand the primary wear-out failure modes in electronics (incorporate Physics of Failure)
- Understand the environment the product needs to withstand (qualification / shipping /storage/user)
- Perform modelling of these failure mechanisms in the expected environments based on known algorithms
- Perform testing (virtual and real) which accelerates the primary failure mechanisms
- Optimize electronics packaging reliability from die level to product level in the presence of uncontrollable user environment

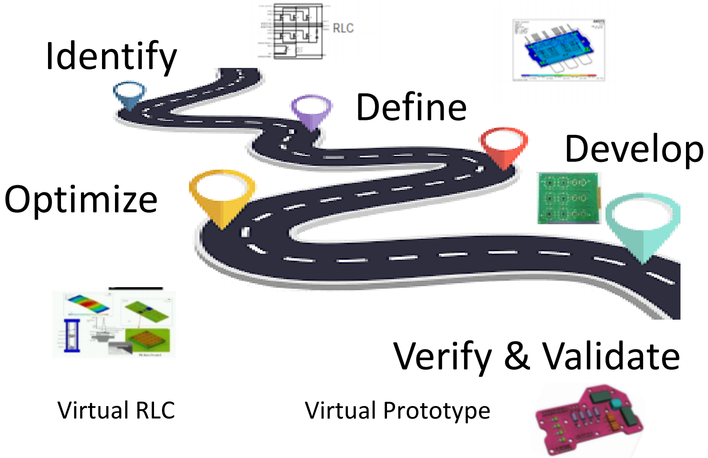
Matthew Hu; 281-299-4230; mhu@rstiglobals.com

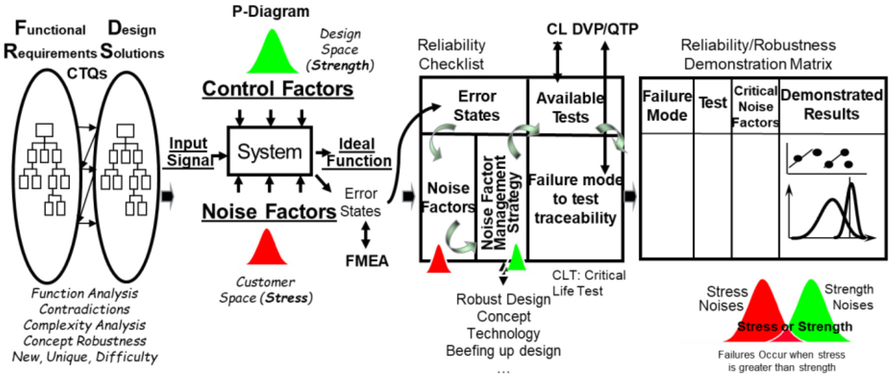
Matthew Hu; 281-299-4230; mhu1529@gmail.com

Robust Design for Reliability Roadmap in Design Process



RRCL: Reliability & Robustness Checklist
RRDM: Reliability & Robustness Demonstration

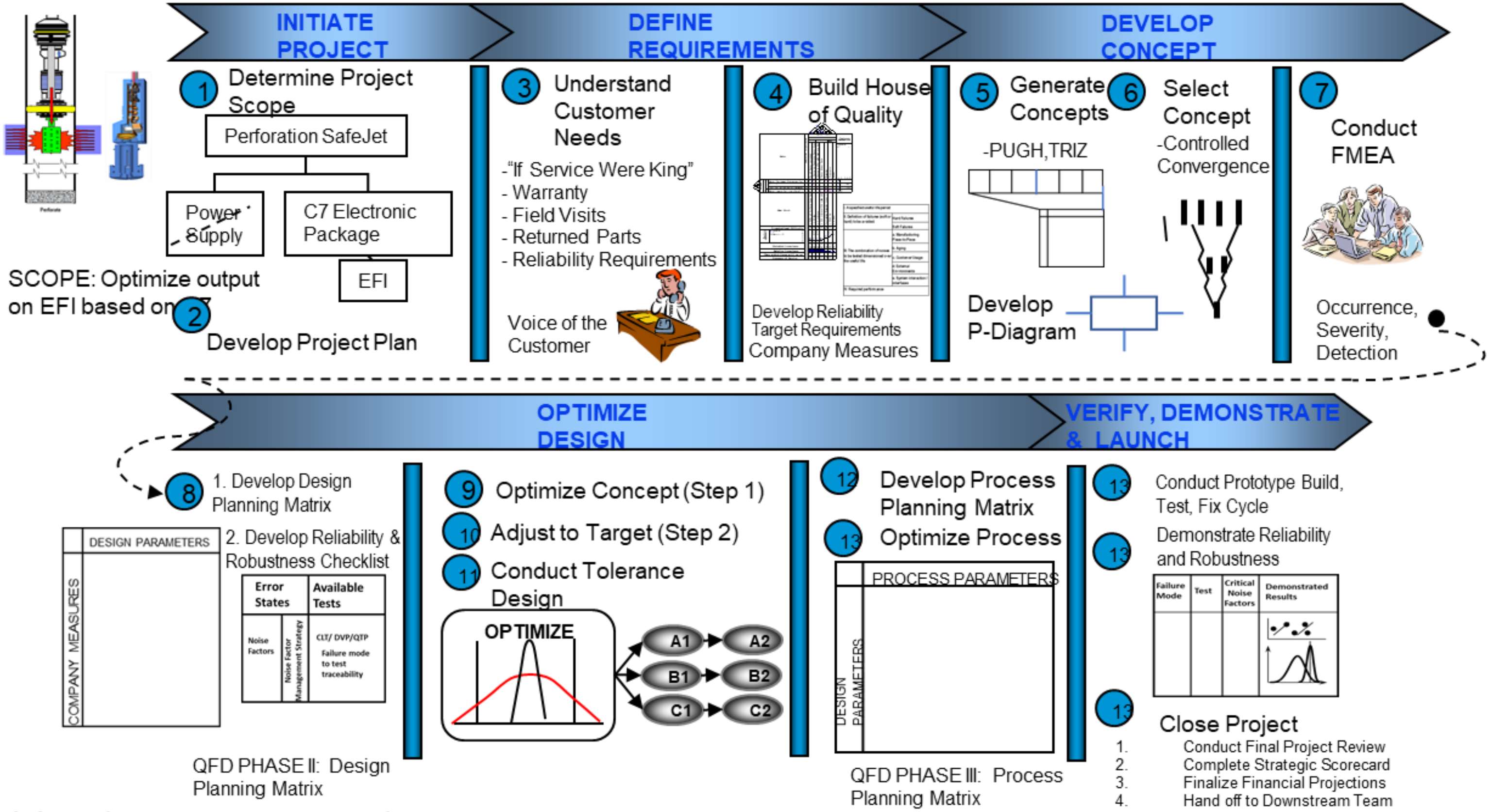




CTQs Development and Management, Risk Assessment and Mitigation

Robust Design for Reliability (*Combined with Design for Six Sigma*)

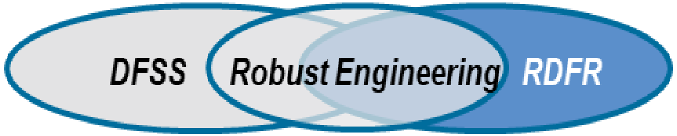
Case Study: An application in Oil/Gas perforating explosive product development

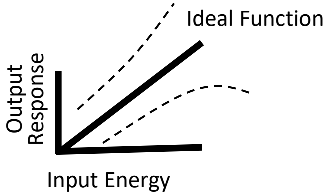


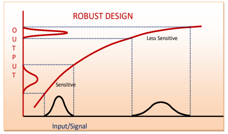
EFI - Exploding Foil Initiator IEC 60079-11 compliance

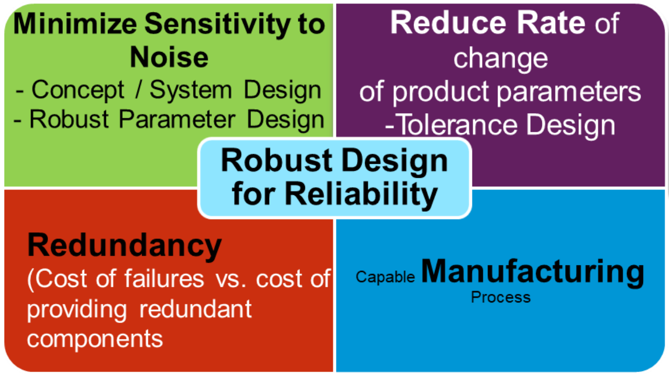
Matthew Hu; 281-299-4230; mhu1529@gmail.com

Summary









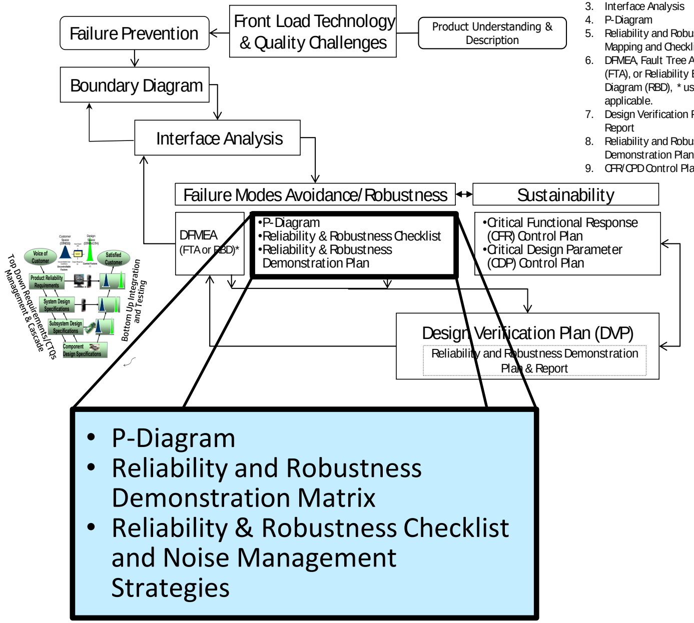
- Adopt the best practices including Robust Design for Reliability
- Start the reliability effort in early design phase
- Take advantage of virtual prototyping
- Electronics packaging reliability from die level to product level

Matthew Hu; 281-299-4230; mhu@rstiglobals.com

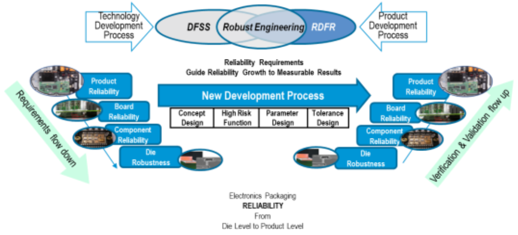
Reliability & Robust Design Training, Seminar Topics Series

1. Robust Design Overview
2. Robustness Thinking in Design for Reliability
3. Advanced Product Quality Planning (APQP)
4. **Engineering Quality Discipline**
5. **P-Diagram**
6. **Reliability and Robustness Demonstration Matrix**
7. **Reliability Checklist and Noise Management Strategies**
8. Robust Design Workshop with Robust Design Green Belt Certification
9. Reliability Target Requirements Development
10. Design for Reliability (DfR) Implementation Scorecard
11. Engineering Confidence vs. Statistical Confidence in Product Testing
12. Basic Design of Experiments (DOE)
13. Quick Quality Function Deployment (QFD)
14. Reliability Prediction using Reliability Block Diagram (RBD)
15. Weibull Analysis
16. Reliability Statistics and Models
17. Reliability and Manufacturing Process Capability (Cp/Cpk /Yield)
18. Advanced Reliability and Robustness Models development through Analytical Models using Computer Aided Engineering (CAE).

Engineering Quality Discipline Linkages



1. Quality/Reliability History
2. Boundary diagram/ Architecture diagram or equivalent
3. Interface Analysis
4. P-Diagram
5. Reliability and Robustness Mapping and Checklist
6. DFMEA, Fault Tree Analysis (FTA), or Reliability Block Diagram (RBD), * use when applicable.
7. Design Verification Plan and Report
8. Reliability and Robustness Demonstration Plan and Report
9. CFR/CPD Control Plan



Matthew Hu; 281-299-4230; mhu@rstiglobals.com