Reliability Program and

Design for Reliability Best Practices

Reliability Activities in Concept Design

ASQ Reliability Forum

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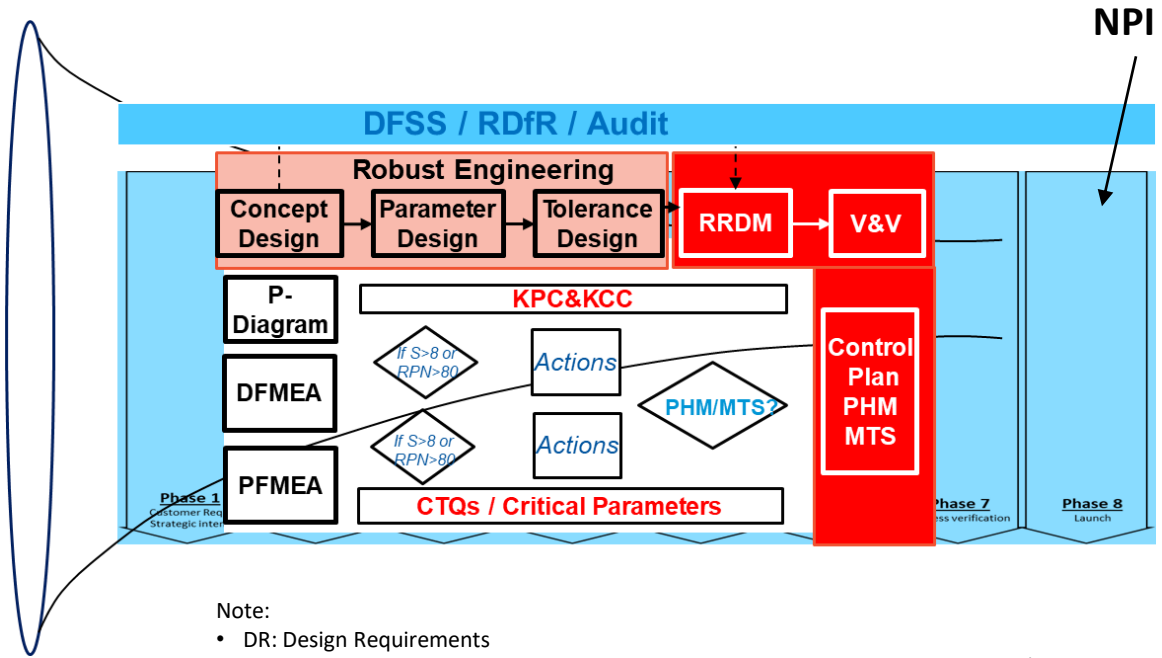
NPI/DfR/DFSS Alignment

- DR
- UAE
- Warranty
- Die
- Components
- Interconnects
- Boards
- LRU
- Wiring
- Systems



Note:

- DR: Design Requirements
- Uncontrollable Application Environment (UAE): N1 Mfg p-p variation, N2: Aging / deterioration, N3: Customer usage, N4: External Environment, N5: System/Subsystem/component interaction/interface
- RRDM: Reliability and Robustness Demonstration Matrix
- V&V: Verification and Validation
- LRU: Line Replaceable Units
- NPI: New Product Introduction

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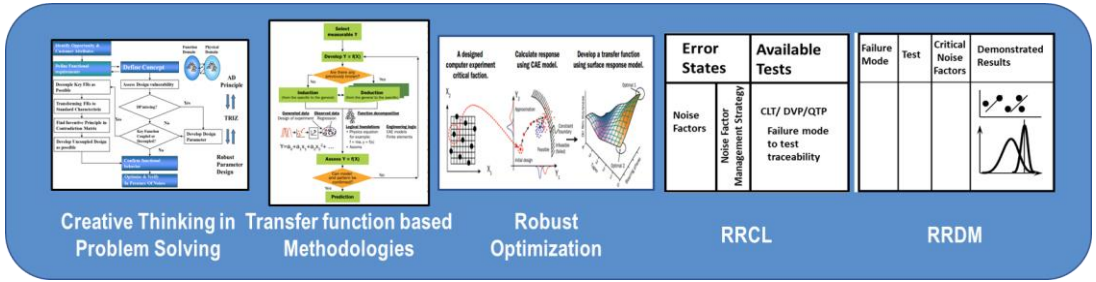
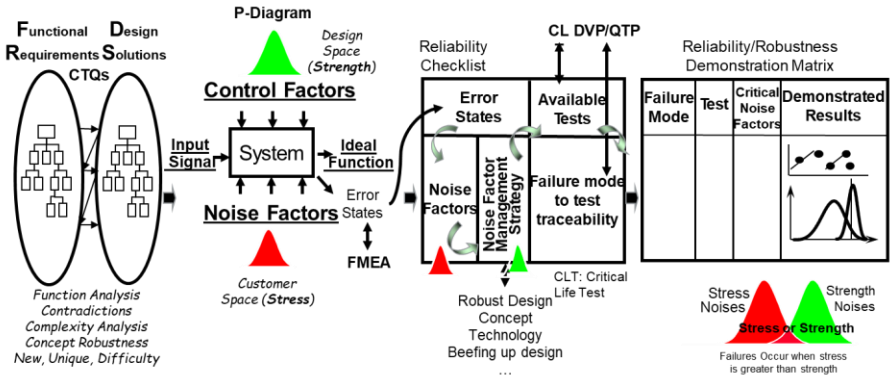
Robust Design for Reliability Roadmap in Design Process



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

Virtual RLC Virtual Prototype



CTQs Development and Management, Risk Assessment and Mitigation

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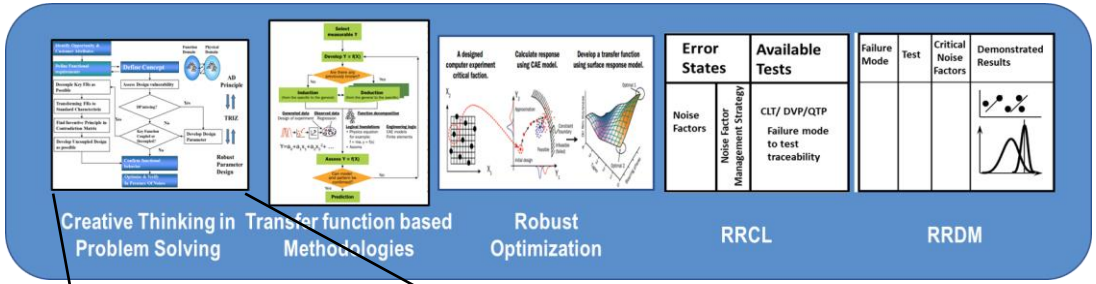
Reliability in Concept Design Example:

Use NUDs Classify Design Functions and Reliability Requirements



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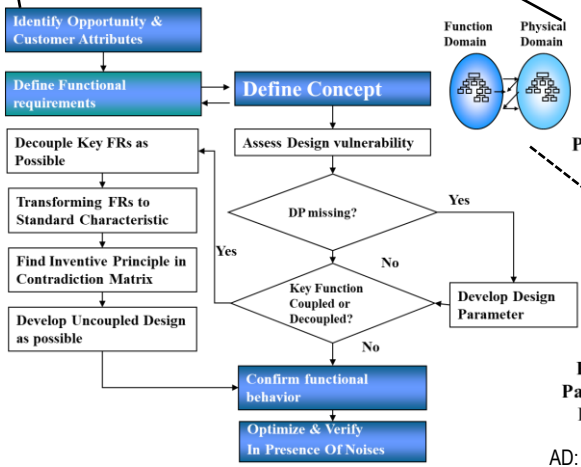
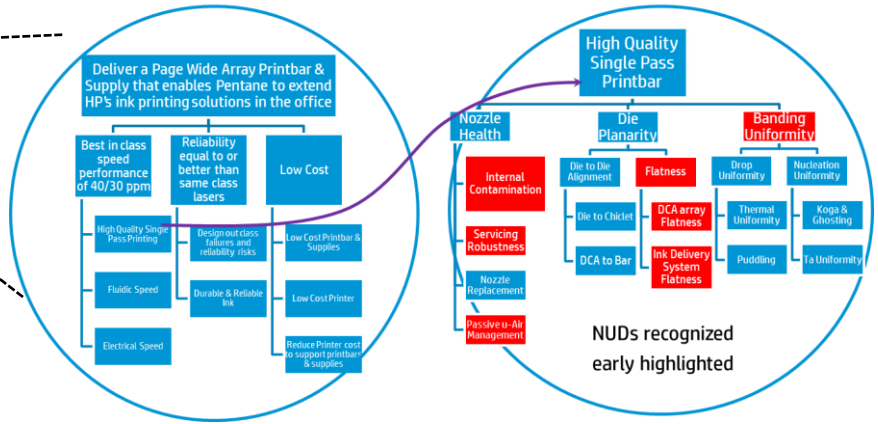


AD Principle

TRIZ

Robust Parameter Design

Printer Concept Design Example:



AD: Axiomatic Design
TRIZ: The Theory of Inventive Problem Solving

NUD: New, Unique, Difficult

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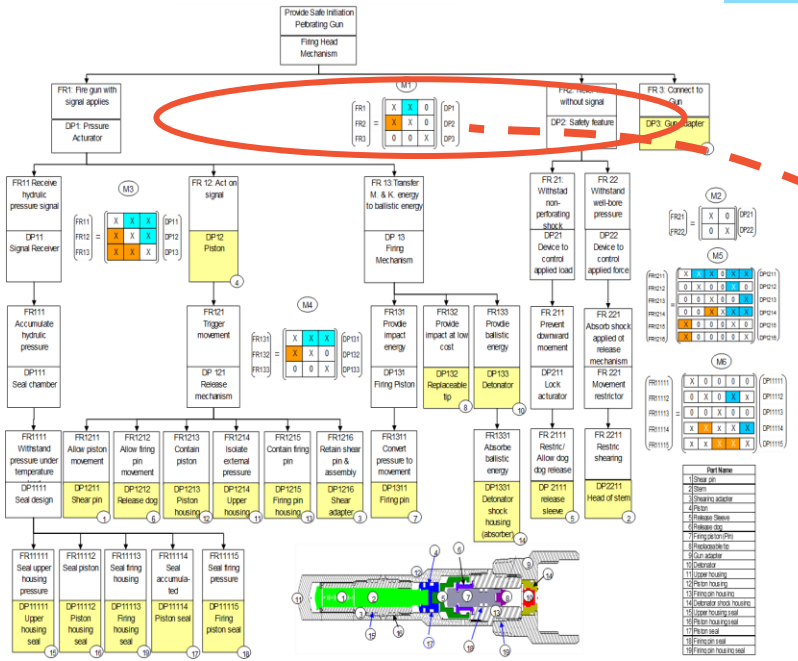
Example: Concept Generation & Health Assessment

Firing Head Design in Oil /Gas Application

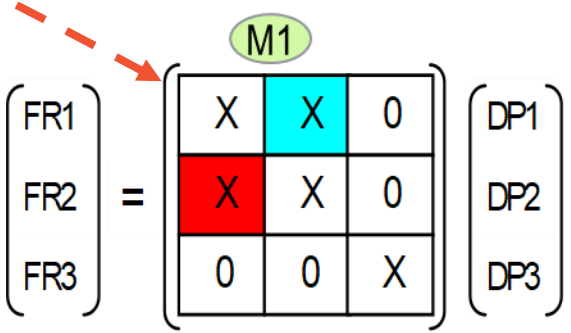


Reliability is derived from the robustness **Inherent** in the product ‘s concept

Develop design concepts to have “**additivity**” in their functional parameters.

Recommendation

Decouple FR1 and FR2 by modifying either DP1 or DP2 design as appropriate



Robustness development acts to prevent problems and reduce risks. Benefits include reduced cycle times and costs.

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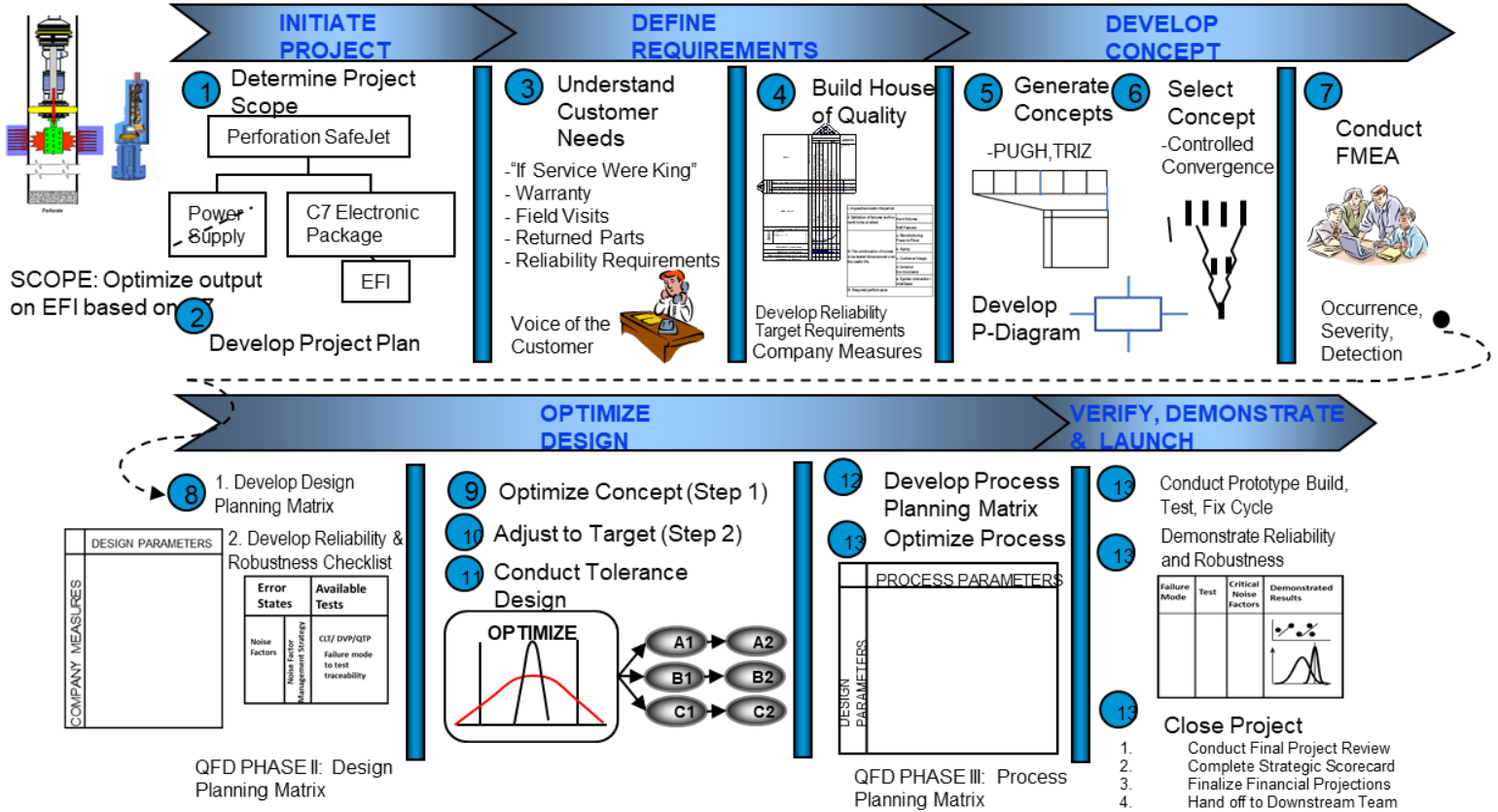
Robust Design for Reliability (*Combined with Design for Six Sigma*)

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



EFI - Exploding Foil Initiator IEC 60079-11 compliance

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Case Study Report Summary (SafeJet Electronic Packaging RDfR)

SafeJet System Reliability Target Requirements

Useful life, Failure modes, Application condition, Expected performan

I. A specified useful life period (5 Years Shelf Life, or some other).		1 Year Shelf Life (date from manufactured (Date/Shift/Code))
II. Definition of failures (soft or hard) to be avoided.	Hard Failures	1. Misfire; 2. Unintended fire
	Soft Failures	1. Take too long to fire; 2. Take too much voltage to fire; 3. Diagnostic error
III. The combination of noises to be tested dimensioned over the useful life.	a. Manufacturing Piece-to-Piece	Manufacturing Process: 1. Capacitor; 2. Spark Gap; 3. EFI; 4. Nonx; 5. Electronics sub assembly; 6. SRC product assembly; 7. Gun shop assembly
	b. Aging	1. Storage in Bunker; 2. Shipping; 3. Storage in assembled gun
	c. Customer Usage	1.Power-up tech.
	d. External Environments	1. Temperature; 2. Humidity; 3. Shock; 4. Vibration; 5. Chemical attack; 6. Pressure; 7. Radiation
	e. System interaction / Interfaces	1. C7/ Spark Gap, 2. EFI to Nonx; 3. Electronic Package
IV. Required performance (Safety & dependability, high con fidence, cost of ownership), ideally from benchmarked competition (default: Secure1), expressed with a robustness demonstration metric, and measuring a distance. (See example as needed)		1. Unintended fire is not acceptable. 2. The likelihood (probability) that there is a 99.34% chance or greater that the Secure 2 will detonate within 3 seconds with input range of 280-360 volts without a misfire is at least 90% in the presence of combined noise factors. 3. This required performance is based on the Secure 1 current reliability performance of 97.25% up to 2009.

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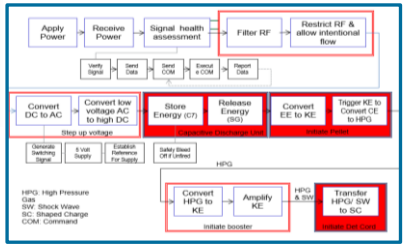
Functional Diagram



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Function and Flow Analysis

SafeJet Functions and Flow

Device/Form		Main Input Flow	Function	Main Output
Charge Pump	Switch	DC	Convert DC to AC	AC
	Multiplier	AC	Covert low voltage AC to higher DC	DC
Electronic Packaging — Capacitive Discharge Unit	Capacitor 7	DC	Store energy	DC
	SG	DC	Release energy	DC
Electronics Assy	Printed Circuit Board & Wire Assembly	Components / Subsystems	Holding all subsystems / components	PWA

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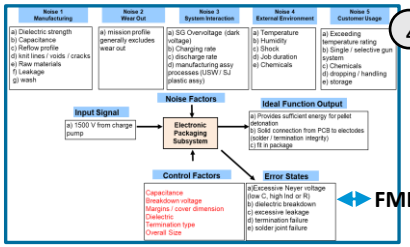
SafeJet C7 (Electronic Packaging P-Diagram)



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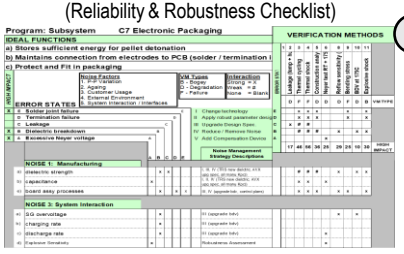
FMEA

SafeJet C7 Electronic Packaging RRCL

(Reliability & Robustness Checklist)



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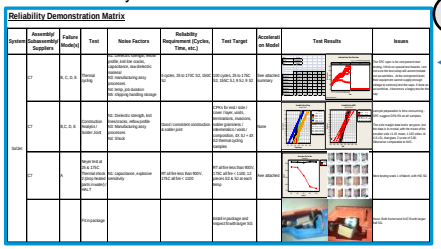
SafeJet C7 Electronic Packaging

Reliability & Robustness Demonstration Matrix



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DRBTR

Design Review Based on Test Results

Confirmed Results and Benefits

- Desensitized detonation reliability to the board manufacturing process.
- Enhanced data based decision-making based on robust barrel optimization study
- Improved and demonstrated 100% reliability & safety performance
- Achieved target performance and zero defect.
- Improved process capability from 0.24 Cpk to 2.18 Cpk
- Reduced $340,000 manufacturing costs annually.

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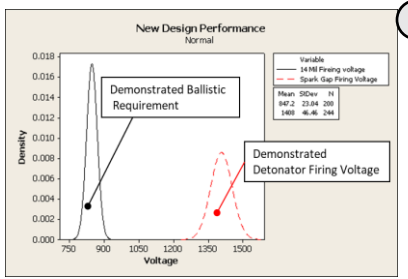

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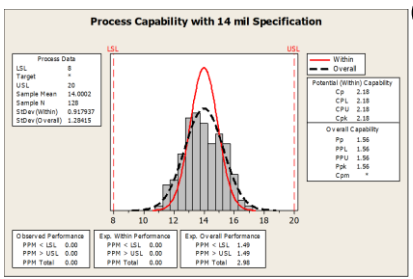

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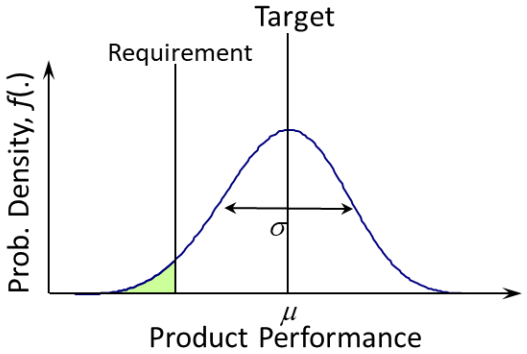
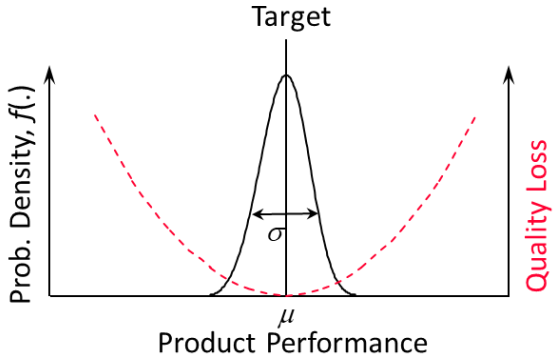
Reliability and Robustness (An Engineering Measure of Reliability) (Robustness Solves the Problem)



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

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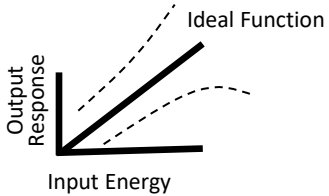
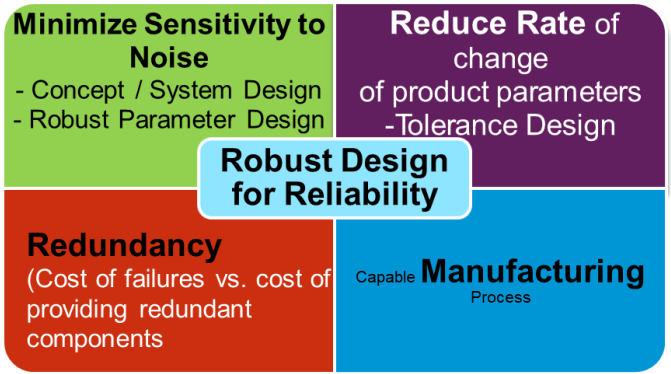
Summary





- 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

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