

Life Extension through Predictive Maintenance

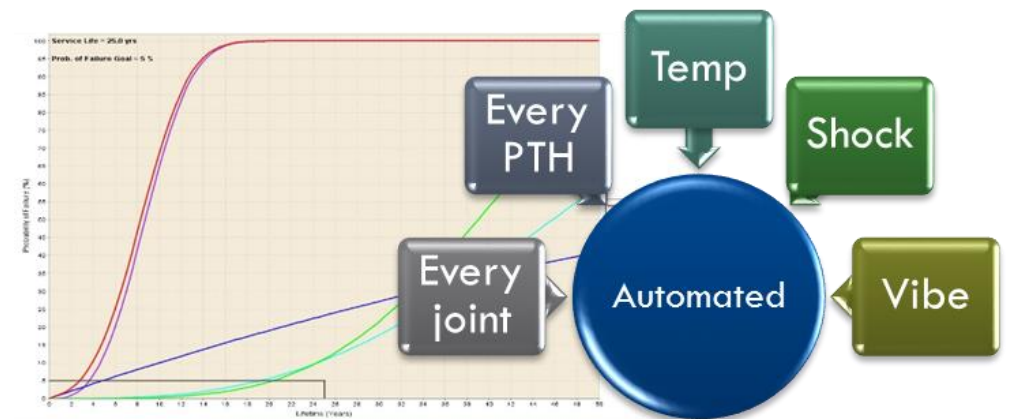


March 25, 2019 | Ed Dodd

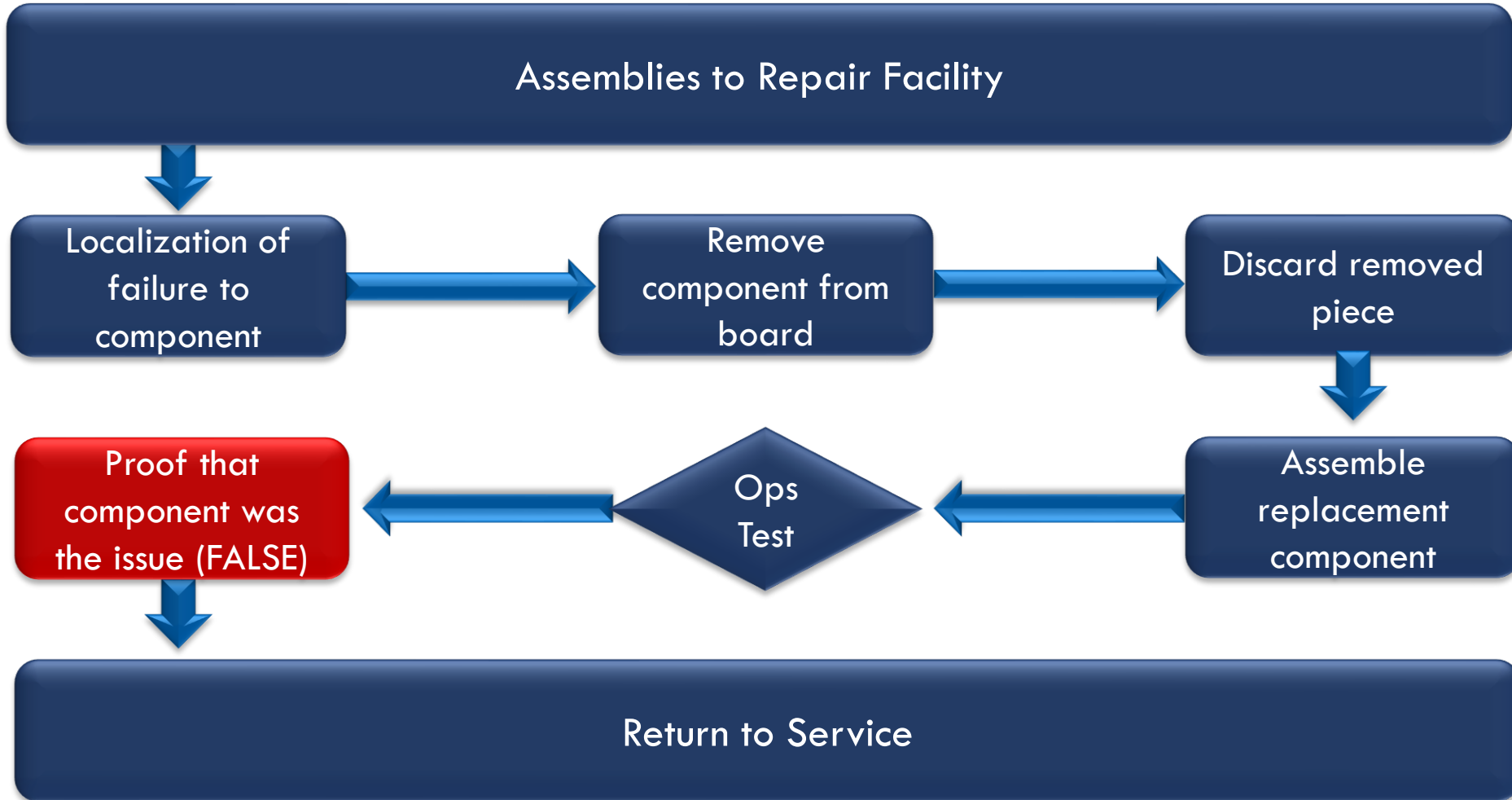
Background: Emerging Advantages of New Capabilities



- **Automated Design Analysis applies reliability physics to electronic assemblies**
 - 60 years of research automated by modern design analysis tools
 - Automated Design Analysis tools are mature (10yrs in market)
 - Calculates time-to-failure at a feature level (component, solder joint, plated through hole)
- **Powerful design assessment tools**
 - Minimize prototyping and test recursion
 - Provide both test and field performance predictions
 - Optimize design of assembly
 - Integrators understand value of external mitigation efforts
- **Only the beginning: What else can we do with this capability?**
 - Package qualification for specific application
 - Test plan development and correlation
 - Functional safety analysis
 - Repair/warranty strategy
 - Predictive maintenance



Assumptions: Simplified Flow of Current Process



Slipping through the Cracks



Solder joint failure accounts for 70% of failures in electronic components

– *Gibson et al., 1997*

Why don't we hear more about this from our repair facilities?

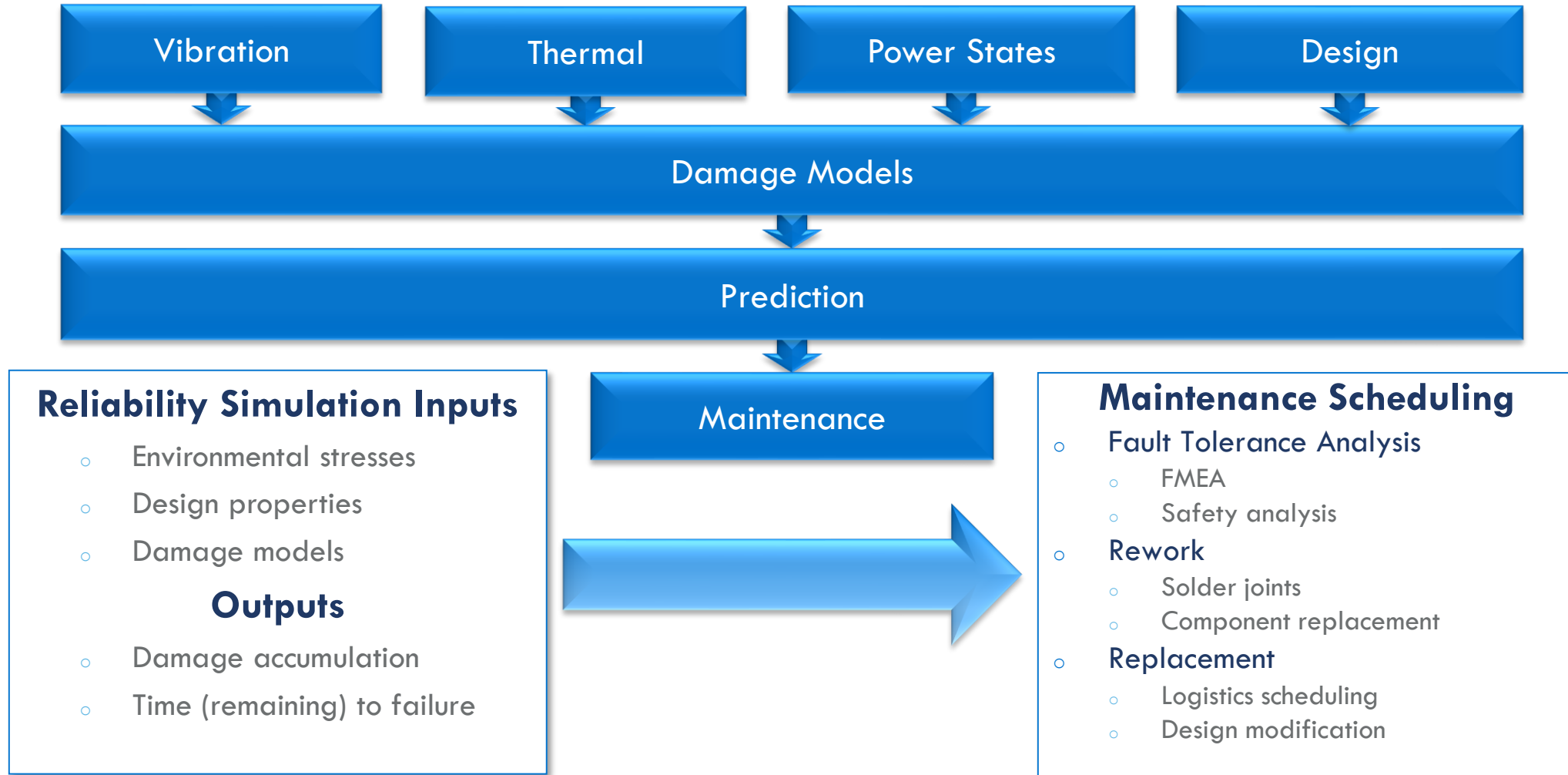
- Solder joint failures can be 'hidden' by the process

When a component is replaced, so are the solder joints

After a component has been replaced, a successful retest is used to confirm component failure and verify a successful repair

- Are solder joint failures component failures?

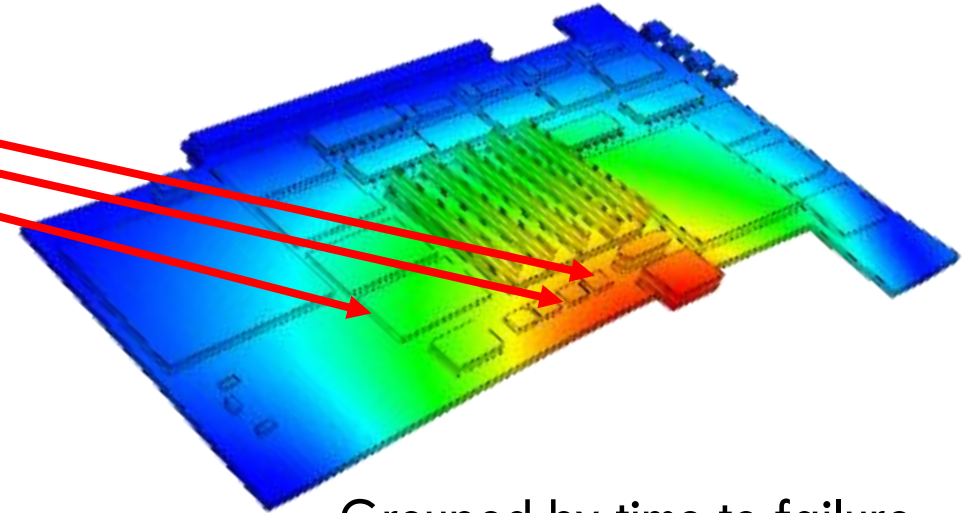
Simulation-Aided Condition Monitoring



Moving Past the Norm: Predictive Condition-Based Maintenance

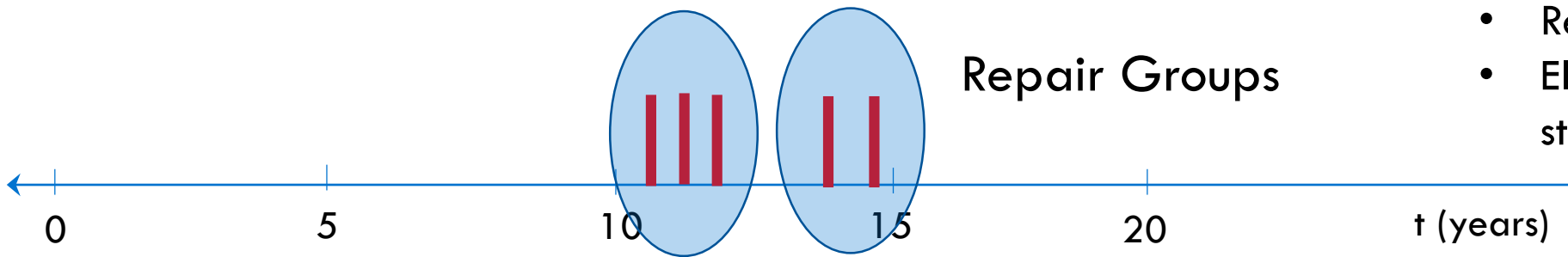


RefDes	Package	Part Type	Side	Solder	Max dT (C)	Cycles to Fail	TTF (yrs)	Score
U11	LCCC-44	IC	TOP	63SN37PB	57.5	5,050	13.84	0.0
U12	LCCC-44	IC	TOP	63SN37PB	57.5	5,050	13.84	0.0
U9	BGA676	IC	TOP	63SN37PB	57.5	13,052	35.76	5.1
U10	BGA676	IC	TOP	63SN37PB	57.5	13,052	35.76	5.1
U13	TSOP-32 (...)	IC	TOP	63SN37PB	57.5	14,083	38.58	6.1
U14	TSOP-32 (...)	IC	TOP	63SN37PB	57.5	14,083	38.58	6.1
U15	TSOP-32 (...)	IC	TOP	63SN37PB	57.5	14,083	38.58	6.1
U16	TSOP-32 (...)	IC	TOP	63SN37PB	57.5	14,083	38.58	6.1
U5	QFN-80 (M...	IC	TOP	63SN37PB	57.5	32,308	88.52	10.0
U6	QFN-80 (M...	IC	TOP	63SN37PB	57.5	32,308	88.52	10.0
R1	2512	RESISTOR	TOP	63SN37PB	57.5	34,105	93.44	10.0
R2	2512	RESISTOR	TOP	63SN37PB	57.5	34,105	93.44	10.0
R3	2512	RESISTOR	TOP	63SN37PB	57.5	34,105	93.44	10.0
R4	2512	RESISTOR	TOP	63SN37PB	57.5	34,105	93.44	10.0
R5	2512	RESISTOR	TOP	63SN37PB	57.5	34,105	93.44	10.0



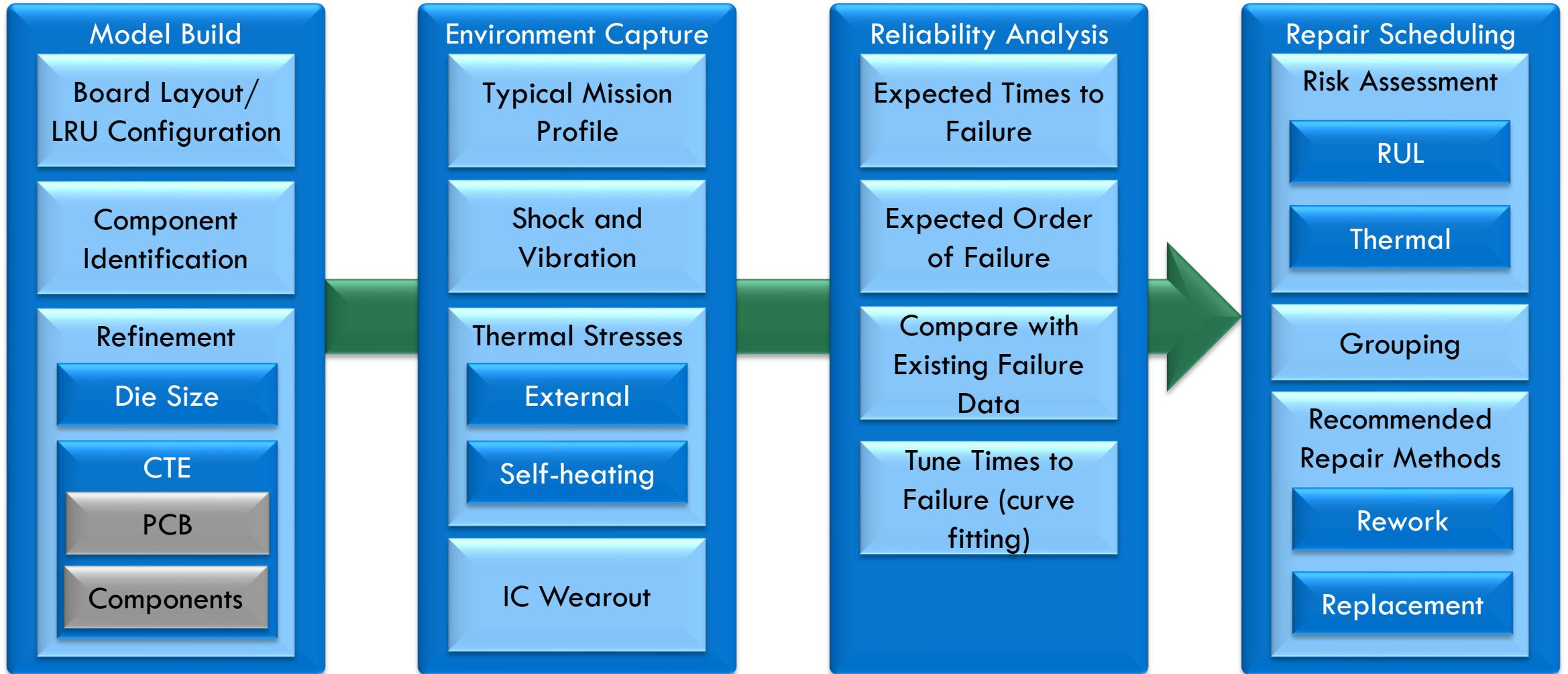
Grouped by time to failure

- Reduce unplanned downtime
- 1st failure as tattle tale
- Relative endurance
- Eliminates need for detailed stress history



Repair Groups

Predictive Maintenance Process



Reduction in Unplanned Downtime



- **Less downtime, greater availability**
 - Grouping repair/rework requirements (e.g., all expected failures in next 3 years)
 - Eliminates multiple failure events
 - › Only the failed component is identifiable
 - › Components near failure still appear deceptively functional
- **Customer satisfaction**
 - Component replacement or refurbishment routine
 - Non-emergency setting
 - Corrective maintenance rarely necessary
- **High reliability applications**
 - Lower risk of failure at critical times

Potential Outcomes – Ideal



70%

of electronics failures are solder joint related*

70%

of the supply pressure may be reduced

70%

of the costs and effort involved in obsolescence risk management may be reduced

*Gibson, A., Choi, S., Bieler, T., & Subramanian, K. (1997). Environmental Concerns and Materials Issues in Manufactured Solder Joints. Proceedings of the 1997 IEEE International Symposium on Electronics and the Environment. San Francisco: IEEE.

Realistic Outcomes



70%

of electronics failures are solder joint related

52%

of the supply pressure may be reduced using 3 to 1 repair/replace ratios

52%

of the costs and effort involved in obsolescence risk management may be reduced

Sustainment Proof of Concept – Successful



- Business jet thrust reverse control unit maintained past reasonable end-of-life
- Indefinite depot repair contract not limited by end-of-life
 - Carried 6-month warranty at box level
 - New failures within 6-month window stressed their business model
- Predictive reliability analysis performed identified component order of failure
 - Schedule of repair updated
 - Failed component AND next failures
- Company was able to optimize their repair process and return the program to profitability