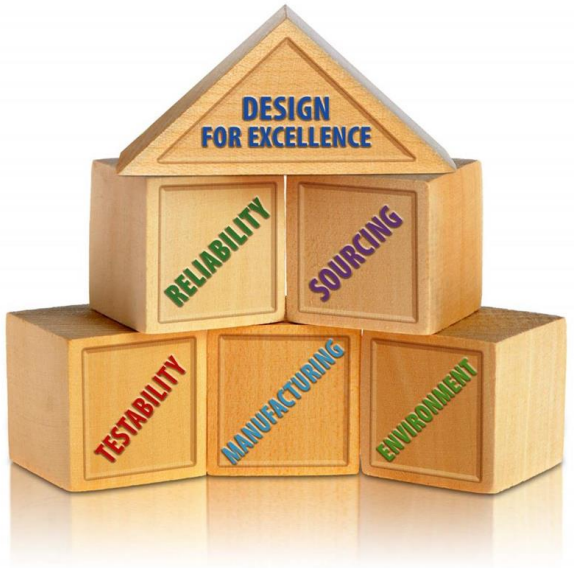
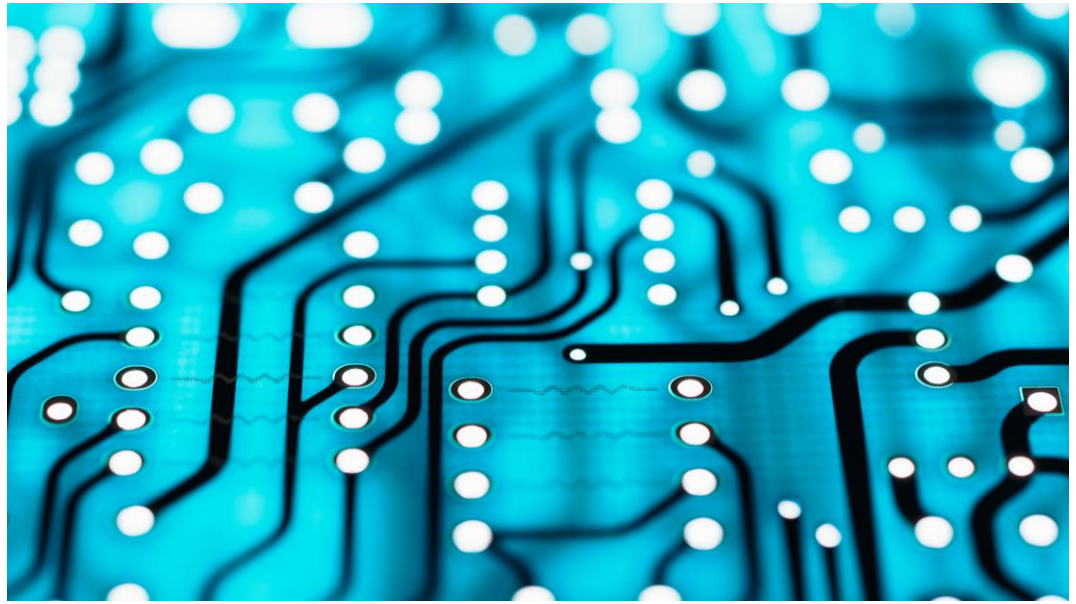




THE ABC'S OF DFX

CHERYL TULKOFF & GREG CASWELL

THE ABC'S OF DFX IN ELECTRONICS MANUFACTURING

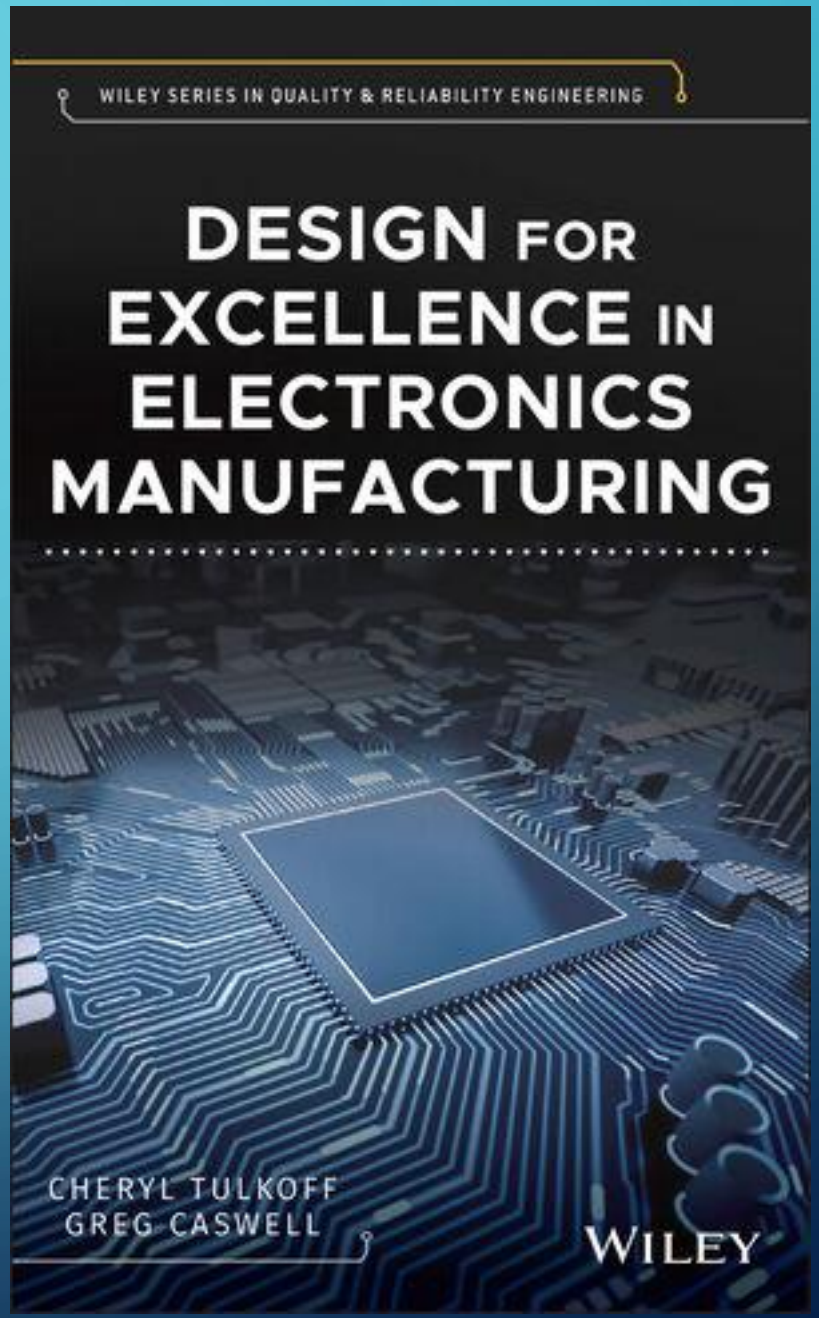
- Focusing only on the cool technology in design limits product success. Having a broad knowledge of the entire product life cycle – from cradle to grave – dramatically improves product quality, reliability, and even productivity.

- Design for Excellence (DfX) is based on the concept that optimizing a product starting early in design is far more effective than fixing problems later. In this webinar, we'll explain how to use the DfX concepts of Design for Reliability, Design for Manufacturability, Design for Environment, Design for Testability, etc., to not only reduce research and development costs but also improve quality and decrease time to market. Understanding DFX concepts is critical for anyone who wants to design and build robust, profitable products. We'll also discuss a few common barriers and mistakes along with some practices you can implement right away.

- Finally, our new book, Design for Excellence in Electronics Manufacturing, offers detailed help covering everything from product ideation to field use. The book shares valuable lessons learned from the real experience including how to select materials for the environment, where to get guidance, and how to use modeling tools to predict product performance. It also helps people spend their test budgets in the best possible way.

DFX BOOK GIVEAWAY

- Answer or ask a question in the chat box and be entered into a drawing for a free autographed (or not) print book shipped to you!



DFX: DESIGN FOR THE FULL PRODUCT LIFE CYCLE

Conception

Useful Life

Obsolescence

INTRODUCTION TO DESIGN FOR EXCELLENCE

EMAIL QUESTIONS

- **What are the best Design Review methods / tools for making DfX analysis? We recommend the reviewer is not the designer, do you?**
  - Agree. Reviews look for issues with the BOM, the circuit board layout and surface finish, the stack-up of the PCB, Moisture Sensitivity, Temperature Sensitivity, and ESD. We also address issues with conformal coating, potting, underfill, other materials utilized, and the effects of the customer's environment. Schematic Reviews may also be part of the process to assess electrical performance. From there it could lead to audits and on-site reviews of manufacturing processes.
- **What are the things to review and consider to optimize the product in the early design?**
  - That is essentially the premise of the entire book. You develop DfR, DfM, DfT analyses of the product as early in the design process as possible. Doing so will address issues in design, component selection, PCB materials and layout, test philosophy, all by looking at the field environment.
- **Do you have any particular comment/caveat about applying DfX concepts in the aerospace industry?**
  - No, the approach we define in the book is applicable across market segments, so they should work fine in your application.
- **What are the commonly used high (Tg) substrates?**
  - I would start with IPC4101/126. That will give you over a dozen materials that have high Tg, High Td, good Dielectric Constant and Dissipation factor. There are over 700 laminates identified as FR-4, so the task of choosing the right material for your application could be daunting.

LEARNING FROM FAILURES: FLUXING & CLEANING

GOOD SUDS

"Beers and Glassware" by Cambridge Brewing Co. is licensed under CC BY-ND 2.0

BAD SUDS

https://images.app.goo.gl/BHHWRpdbZjjinYTJA

MISTAKES MADE

1ST ROBOTIC PICK AND PLACE FOR SMT

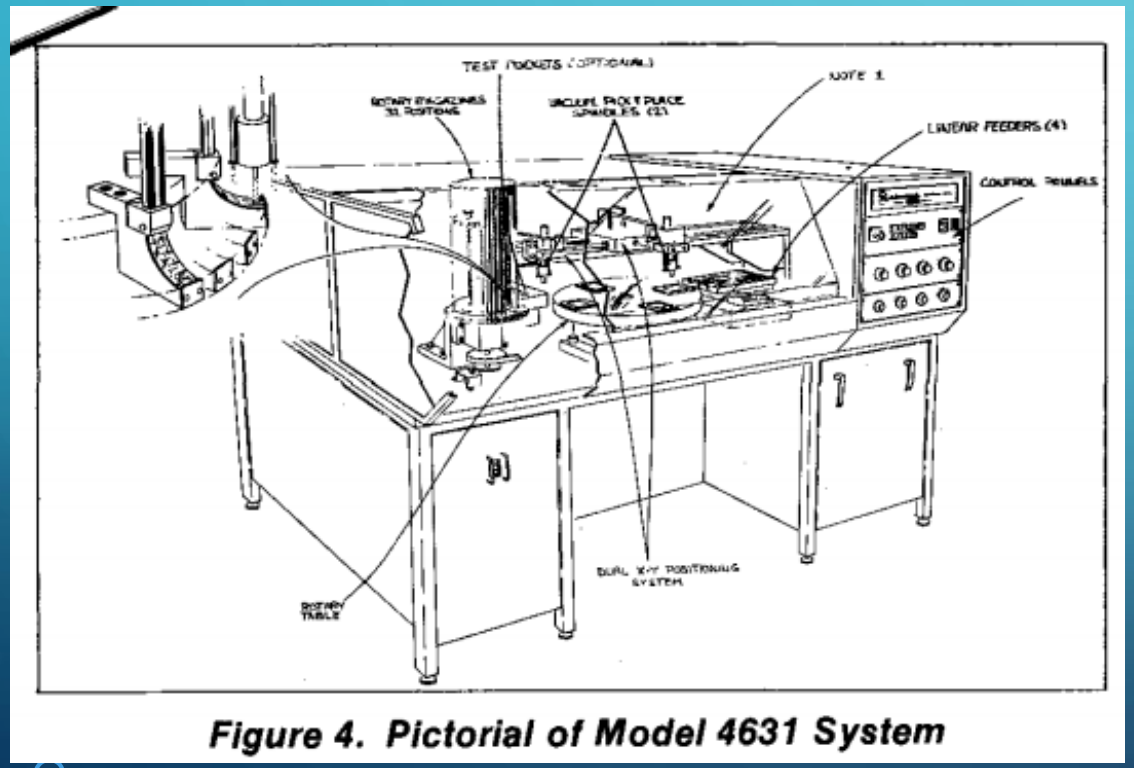
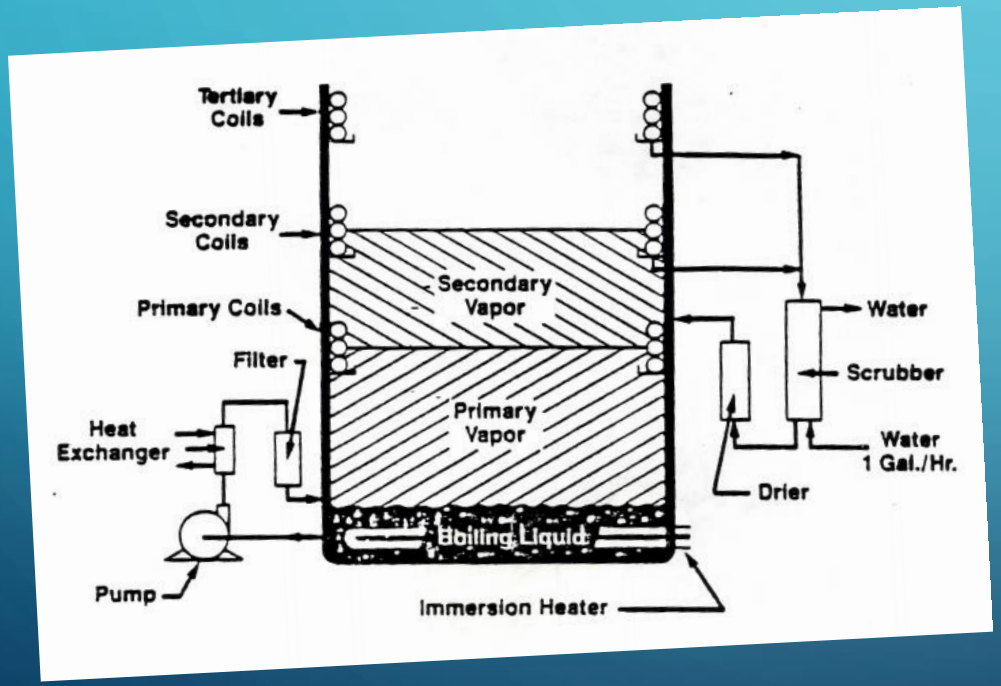


Figure 4. Pictorial of Model 4631 System

- Universal Instruments RhyMas II Pick and Place System
  - 300 parts per hour placement speed
  - Accuracy 1 mil
  - Vertical aluminum feeders for ICs
  - Bowl feeders for 1206 size capacitors and resistors
  - Controlled by a Tandy II computer

MISTAKES MADE

VAPOR PHASE SOLDERING



MORE CURRENT PROJECTS

DASH MOUNTED RADIO

AUTOMOTIVE AIR BAG

THERMAL TRANSFER SYSTEM

THE BOOK PROCESS:
IT SEEMED PRETTY SIMPLE!

New Book Proposal Process

Title & Author(s)

Vision

- Description of the book you want to write
- Reader Background

Market for the Book

- Primary and Secondary audience(s)
- Job titles where possible

Manuscript Information

- How many pages & graphs?
- How long will it take to write?

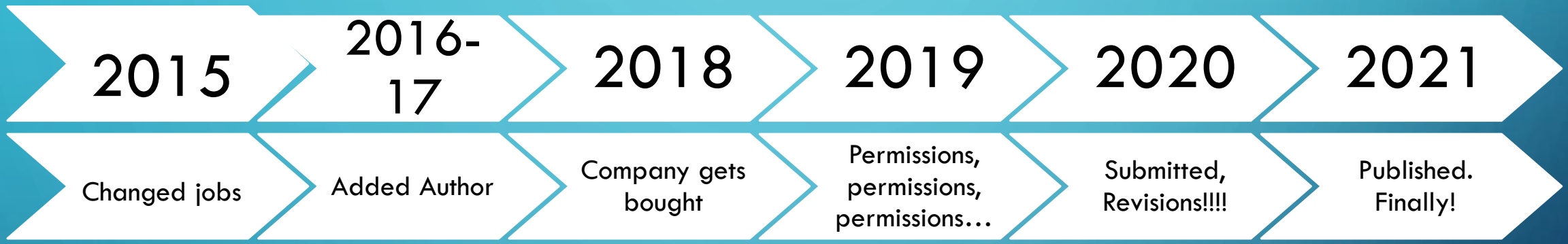
Author(s) Info

- Why you?
- Why you're compelling?

Concept Reviewers & Acceptance

- Expert review
- Would you buy it?

WHAT DIDN'T GO AS PLANNED?



New tools

Author Changes

COVID

BUT WE DID LEARN TO WRITE GOOD!!!

1) Avoid Alliteration. Always
2) Prepositions are not words to end sentences with.
3) Avoid clichés like the plague. They're old hat.
4) Comparisons are as bad as clichés.
5) Be more or less specific.

Six) Be consistent!

7) Don't be redundant; don't use more words than necessary; it's highly superfluous

8) Who needs rhetorical questions?

9) Exaggeration is a billion times worse than understatement.

DESIGN FOR EXCELLENCE

- Chapter 1 outlines what will be addressed in the next 7 chapters
  - Designing for Excellence (DfX) is a methodology where multiple functional groups with knowledge of different parts of the product lifecycle advise the design engineering functions beginning in the concept phase.
  - The process of assessing issues beyond the core functionality where core functionality is defined as meeting the business and customer expectations of function, cost, and size.
  - Key elements of a DfX program include design for reliability, manufacturability, sourcing, and the environment.
  - DfX efforts require the integration of product design and process planning into a cohesive, interactive activity

CHAPTER 2

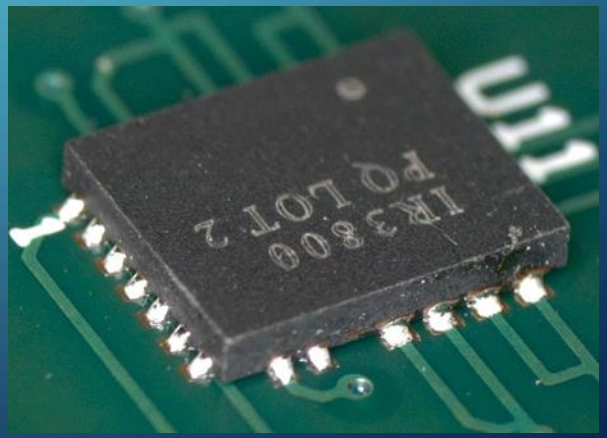
- Establishing a Reliability Program
  - A comprehensive, well-thought-out reliability program ensures that companies achieve their quality, reliability, and customer satisfaction targets:
    - on time, on schedule & within budget
  - Reliability = measure of a product's ability to perform the specified function at the customer (with their use environment) over the desired lifetime.
  - Reliability is specific to each & every application - there is no "one size fits all"
  - Desired lifetime and product performance metrics must be identified and documented.

RELIABILITY GOALS

- Identify and document two key metrics
  - *Desired lifetime*
    - Defined as time the ***customer*** is satisfied with
    - Should be actively used in development of part and product qualification
  - *Product performance*
    - Returns during the warranty period
    - Survivability over lifetime at a set confidence level

KEY DESIGN CONSIDERATIONS

- Reliability goals
- End use environment
- PCB substrate & surface finish selection
- Component selection, finish & placement
  - Manual attachment



CHAPTER 3

- Design for Reliability
  - Design for Reliability is the process for ensuring the reliability of a product or system during the design stage before physical prototypes are made.
  - Crucial elements of a DfR program include setting specifications at the concept and/or block diagram stage, selecting suppliers and parts, and considering wearout mechanisms and physics of failure for the use environment.
  - After reliability expectations have been identified, the next step is to define the use environment.

UNDERSTANDING REQUIREMENTS

Inputs include:

- Regulations
- Specifications
  - MRD – Marketing Requirements Document
  - PRD – Product Requirements Document
- Competitive Product Solutions
- Lessons Learned
- Constraints

UNDERSTANDING REQUIREMENTS

- Risks comes From Requirements That Are
  - Incomplete
  - Ambiguous
  - Conflicting
  - Not Testable

DESIGNING TO REQUIREMENTS
MECHANICAL

- Common Hardware
- Minimize Part Count
- Feature Integration
- Design For Assembly
- Design For Test
- Design for Service

DESIGNING TO REQUIREMENTS
ELECTRICAL

- Select Parts With Long Lifetimes
- Design For Assembly
- Design For Test
  - In-Circuit Test
  - Functional Test
- Design for Service

CHAPTER 4

- Design for the Use Environment: Reliability Testing and Test Plan Development
- Product test plans are critical to the success of a new product or technology. Plans need to be stressful enough to identify defects yet show a correlation to a realistic environment. The recommended approach is to employ both industry standards and Reliability Physics (RP). This approach results in an optimized test plan that is acceptable to management and customers.
- Utilizing Reliability Physics to facilitate the design, performance, and resulting interpretation of accelerated life tests, starting at the design stage of a product and continuing throughout the life cycle of the product, is the ideal methodology for creating a viable test plan.

UNDERSTAND USE ENVIRONMENT

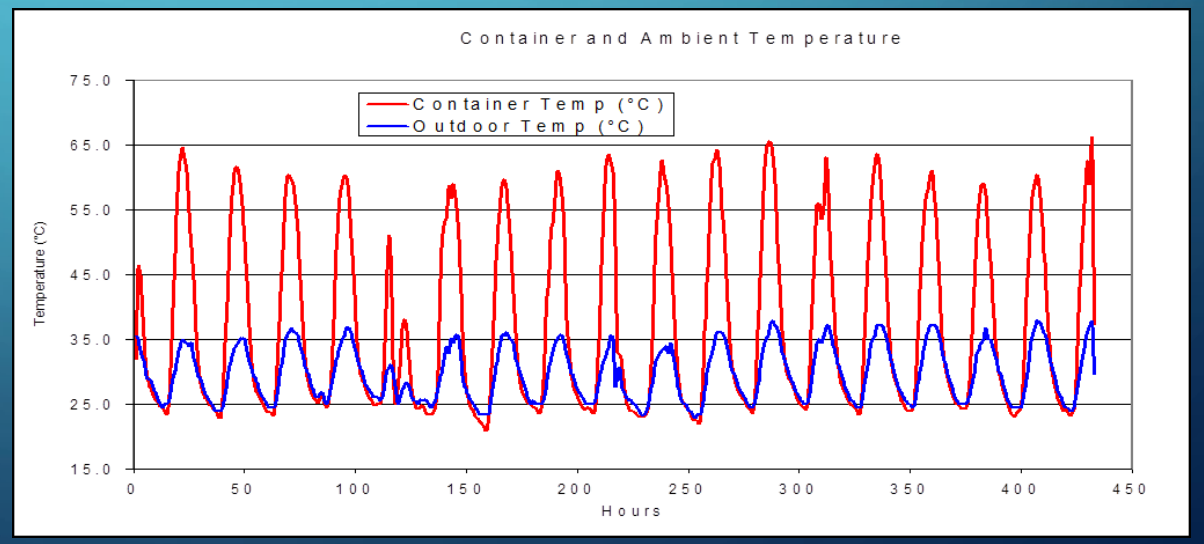
- What are normal use conditions?
- What are typical abuse conditions?
- What are atypical (but real) abuse conditions?
- What is life of product?

END USE ENVIRONMENT

- Critical first step is a good understanding of the shipping and use environment for the product
- Understand the customer & how they use the product
- How well is the product protected during shipping (truck, ship, plane, parachute, storage, etc.)?
- Is data available?
  - Temp/humidity, thermal cycling, ambient temp/operating temp.
  - Salt, sulfur, dust, fluids, etc.
  - Mechanical cycles (lid cycling, connector cycling, torsion, etc.)

USE ENVIRONMENT (CONT.)

- Better Approach: actual measurements of similar products in similar environments
  - Determine average & worst-case
  - Identify all failure-inducing loads
  - Include <u>all</u> environments
    - Test
    - Manufacturing
    - Transportation
    - Storage
    - Field

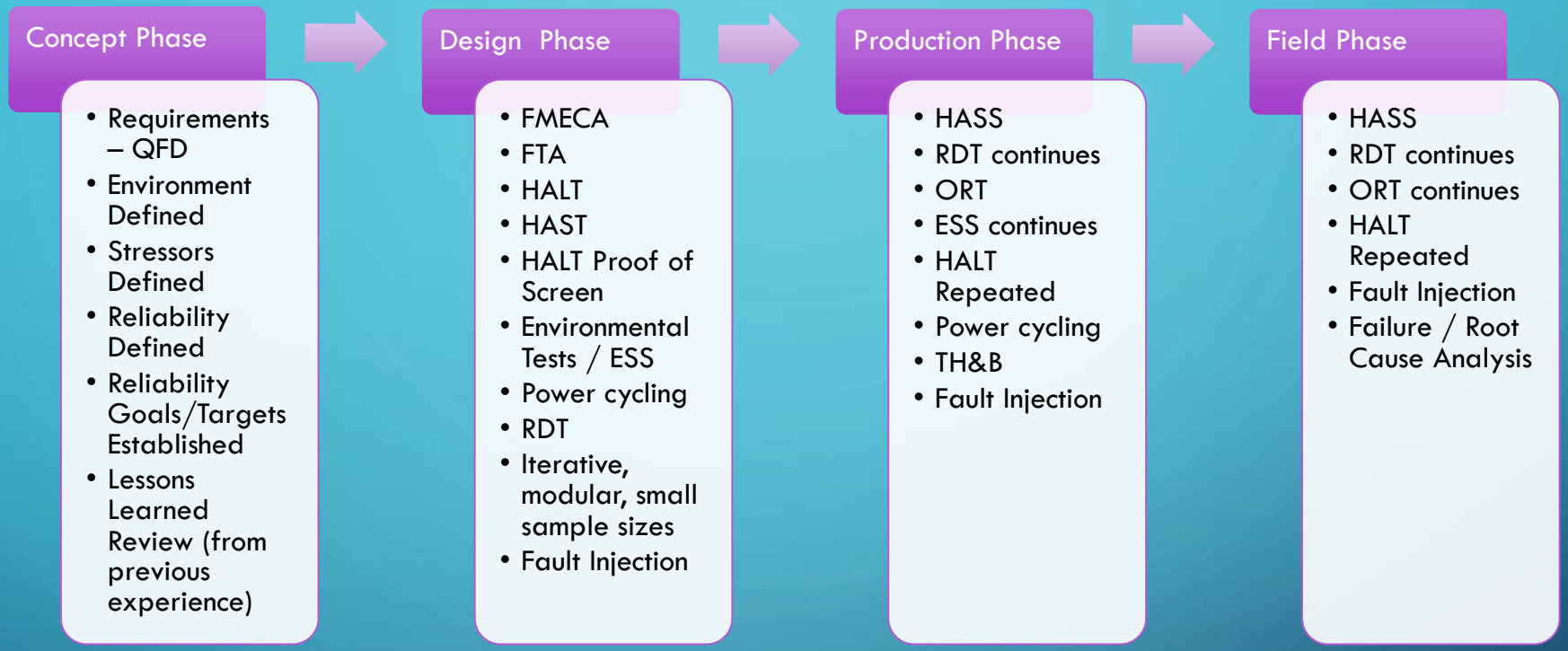


CRITICAL ELEMENTS FOR DEVELOPING ROBUST TEST PLANS

- Test Objectives
  - Comparison
  - Qualification
  - Validation
  - Research
  - Compliance
  - Regulatory
  - Failure analysis

- Elements
  - Reliability Goals
  - Design
  - Materials
  - Use Environment
  - Budget
  - Schedule
  - Sample availability
  - Practicality
  - Risk

RELIABILITY TOOLS/TESTS ACROSS THE DES. & DEV PHASES



QFD: Quality Functional Deployment (House of Quality)
FMECA: Failure Modes, Effects, and Criticality Analysis
FTA: Fault Tree Analysis
HALT: Highly Accelerated Life Testing
HAST: Highly Accelerated Stress Testing (T+P)

ESS: Environmental Stress Screening
RDT: Reliability Demonstration Testing
ORT: Ongoing Reliability Testing
THB: Temp, Humidity, & Bias

DFX SUMMARY

- To avoid design missteps, be aware that functionality is just the beginning. Design reliability in!
- Be aware of industry lessons learned
- Maximize knowledge of your design as early in the product development process as possible
- Practice design for excellence (DfX)
  - Design for manufacturability
  - Design for sourcing
  - Design for reliability
  - Design for environment

CONCLUSIONS

- Design for Excellence is a valuable process for lowering cost, reducing time-to-market, and improving customer satisfaction
- Successful DfX / implementation requires the right combination of personnel and tools under market time constraints

Design for Excellence in Electronics Manufacturing: Available in print or ebook formats

Also available at:
Amazon
Barnes & Noble

Connect with me on LinkedIn!

SPEAKER BIOGRAPHY

ctulkoff@gmail.com

- I have over 30 years of experience in electronics manufacturing focusing on reliability and failure analysis. I'm passionate about applying my unique background to accelerate product design and development while improving reliability, optimizing resources, and improving customer satisfaction.

- Throughout my career, I've had extensive experience training others. I'm a published author, a senior member of both ASQ and IEEE and a volunteer for IPC & SMTA. I'm also a ASQ Certified Reliability Engineer and Certified Manager of Quality and Organizational Excellence.

- I earned a Bachelor of Mechanical Engineering degree from Georgia Tech and a Master of Science in Technology Commercialization (MSTC) program at the University of Texas at Austin.

- In my free time, I love to run! I've had the good fortune to run everything from 5k's to 100 milers including the Boston Marathon, the Tahoe Triple (three marathons in 3 days) and the nonstop Rocky Raccoon 100 miler. I also enjoy travel and have visited 46 US states and over 36 countries around the world. I combine these two passions in what I call "running tourism" which lets me quickly get my bearings and see the sights in new places.

SPEAKER BIOGRAPHY: GREG CASWELL

gkcaswell@gmail.com

- Greg has over 50 years of experience in electronics manufacturing focusing on failure analysis and reliability. He is passionate about applying his unique background to enable his clients to maximize and accelerate product design and development while saving time, managing resources, and improving customer satisfaction.

- Greg, a Lead Consulting Engineer for Ansys, is an industry recognized expert in the fields of SMT, advanced packaging, printed board fabrication, circuit card assembly, and bonding solutions using nanotechnology. He has been well-regarded as a leader in the electronics contract manufacturing and component packaging industries for the past 50 years. Prior to joining Ansys Greg was the Vice President of Engineering at Reactive Nanotechnology (RNT), where he led application development for the RNT Nanofoil® and ensured a successful transition of product technology to Indium Corporation. His previous appointments include Vice President of Business Development for Newport Enterprises, Director of Engineering for VirTex Assembly Services, and Technical Director at Silicon Hills Design. He has presented over 270 papers at conferences all over the world and has taught courses at IMAPS, SMTA and IPC events. He helped design the 1st pick and place system used exclusively for SMT in 1978, edited and co-authored the 1st book on SMT in 1984 for ISHM and built the 1st SMT electronics launched into space. Look for his new book entitled “Design for Excellence in Electronics Manufacturing” published in April 2021.
- B.A., Management (St. Edwards University); B.S., Electrical Engineering (Rutgers University)
- In my free time I play with my restored 1951 Chevy Bel Air.