



**Agilent Technologies**

# **Fundamentals of Manufacturing**

**"Reducing Cost of Manufacturing Lifecycle Through  
Understanding the Value Of Test"**

**June 19, 2001**

*presented by:*

**Duane Lowenstein**

Americas Strategic  
Business Development Manager

# Profile of Speaker

## Duane Lowenstein



- **Manager of America's Strategic Business Development Organization**
- **20 years experience in manufacturing**
- **Professional positions include Production/Manufacturing Manager, New Product Introduction Manager**
- **BS degree in Mechanical Engineering from Rutgers University**
- **MBA from Penn State University**



# Learning Objectives

- 1. Understanding the value of test as an inspection process step within the manufacturing lifecycle.**
- 2. Map different test strategies to different phases of the manufacturing lifecycle and be able to identify mismatches:**
- 3. Articulate how cost tradeoffs effect manufacturing processes and enterprise business results;**
- 4. The role test plays in achieving manufacturing performance improvement.**

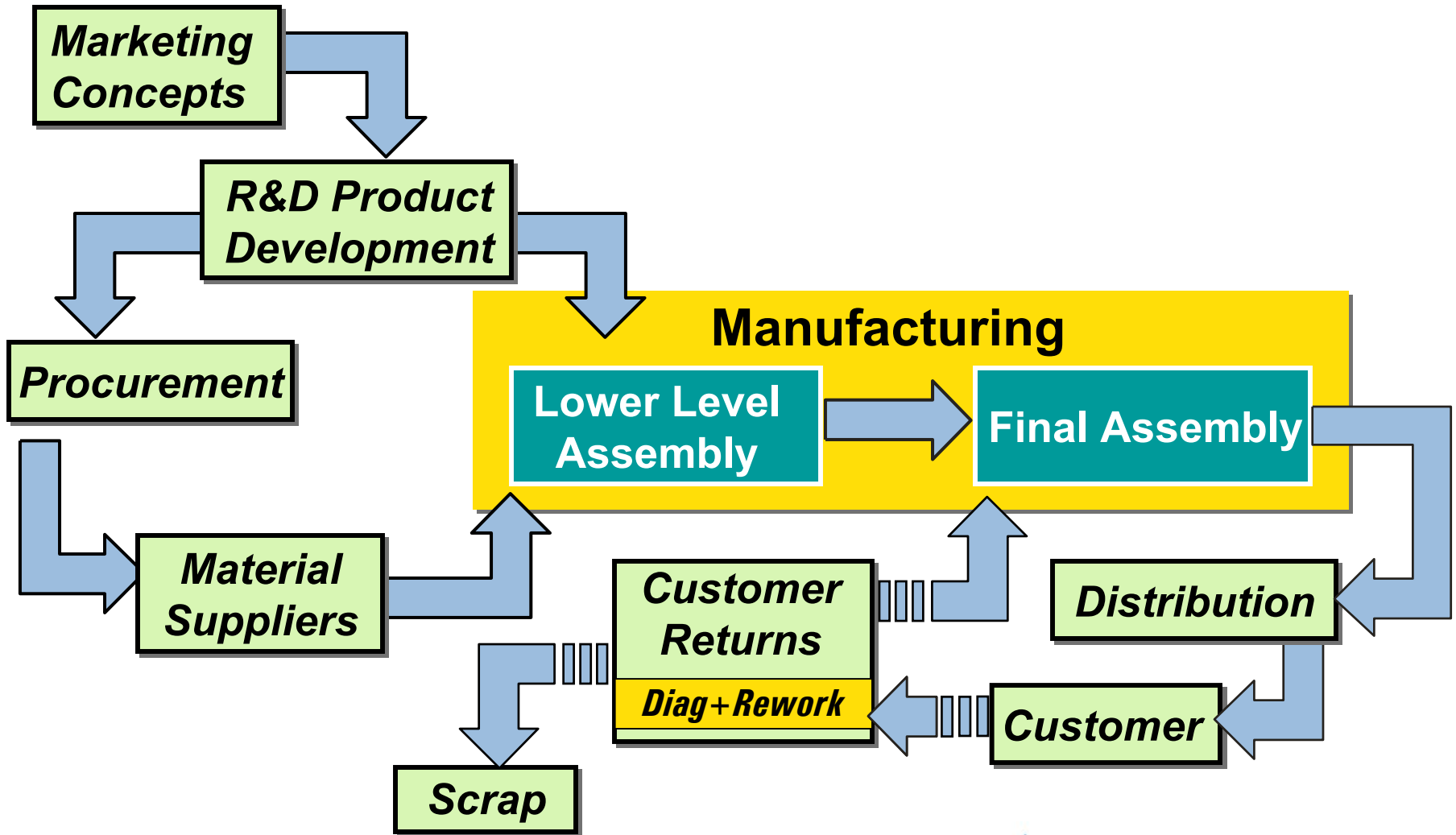


# Agenda

- **Brief review of key electronic manufacturing parameters**
- **Test and cost drivers**
- **Using test to improve performance**
- **Sorting through the complexity**
- **The impact of TTM**
- **Case study example**
- **Summary / resources / Q&A**

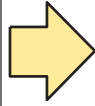


# Simplified Systems View of Business

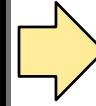


# Standard Test Strategy

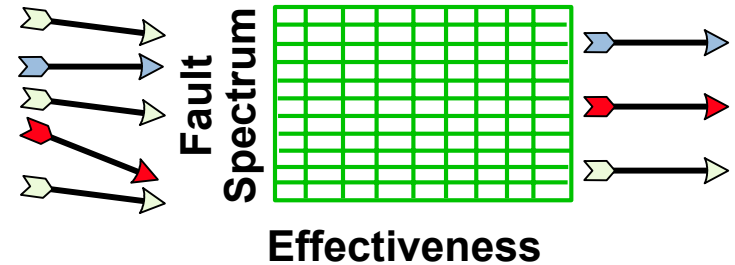
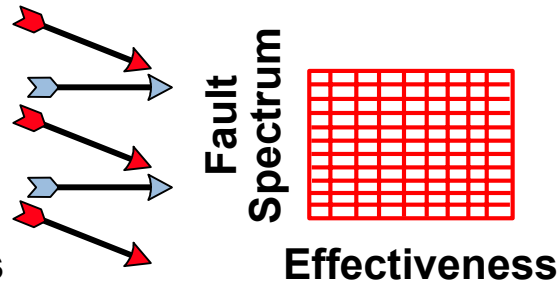
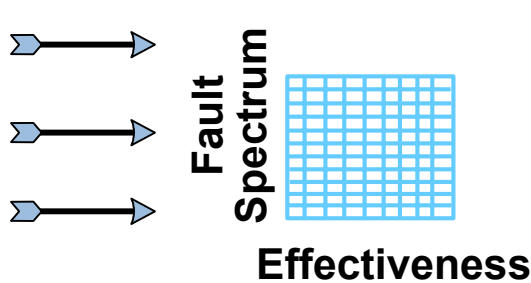
**SMT  
w/Visual Test**



**Thru-hole & Sub-Assy  
w/ICT & Card Test**

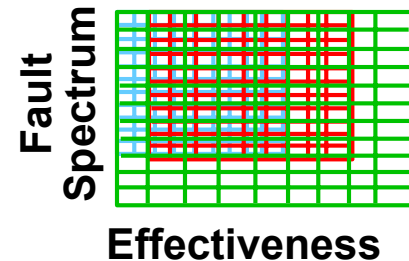


**Final Assy w/Top Level,  
ESS & Post Test**

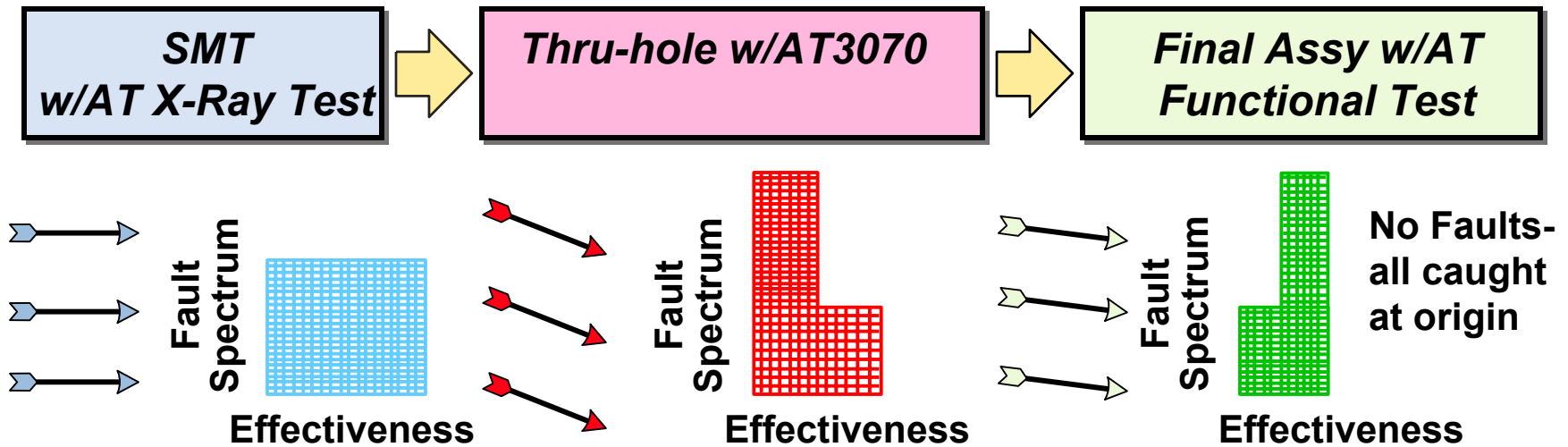


## Focus on:

- ✘ Broad coverage at each test
- ✘ High level redundant test
- ✘ Leakage of early defects caught later by test
- ✘ Fault coverage is unpredictable

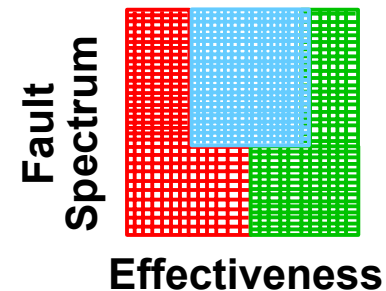


# Optimized Test Strategy



## Focus on:

- ✗ Test in right place
- ✗ Minimize redundant test
- ✗ Effectively catch defects at origin
- ✗ Fault coverage is predictable



# Test and Cost Drivers



## *Functions*

- Prototypes per year
- Turns per prototype
- Time to develop test
- Time to market without test
- Component types
- Interconnect technology
- Re-occurring test costs

## *Cost Factors*

- # Prototype test fixtures
- Delay to test product due to debug of test
- Delay of product to market because of test
- Delay due to test gaps





# Test and Cost Drivers



## *Functions*

- Time to test
- Time to diagnose
- Time to repair
- Test coverage
- Cycle time between cause and test detection
- Time to get process in control Prototypes per year

## *Cost Factors*

- Time to test
- Cost of visual inspection
- Defects caught at functional test
- Cost of diagnostics and repair
- Process not in control
- Cost of 'bone pile'



# Test and Cost Drivers



## *Functions*

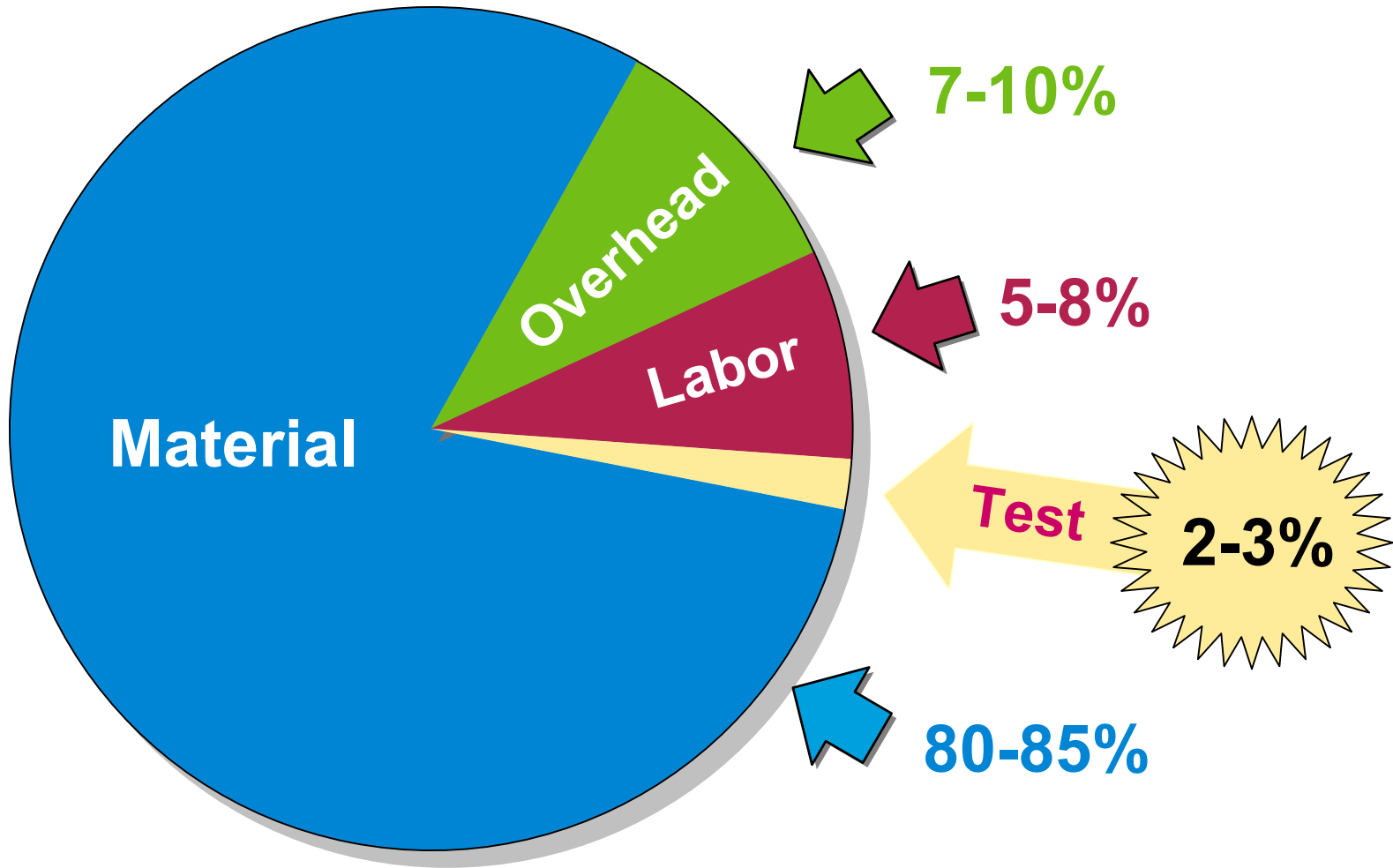
- # returns
- Time to diagnose
- # of returns due to manufacturing defects
- # of returns due to design defects

## *Cost Factors*

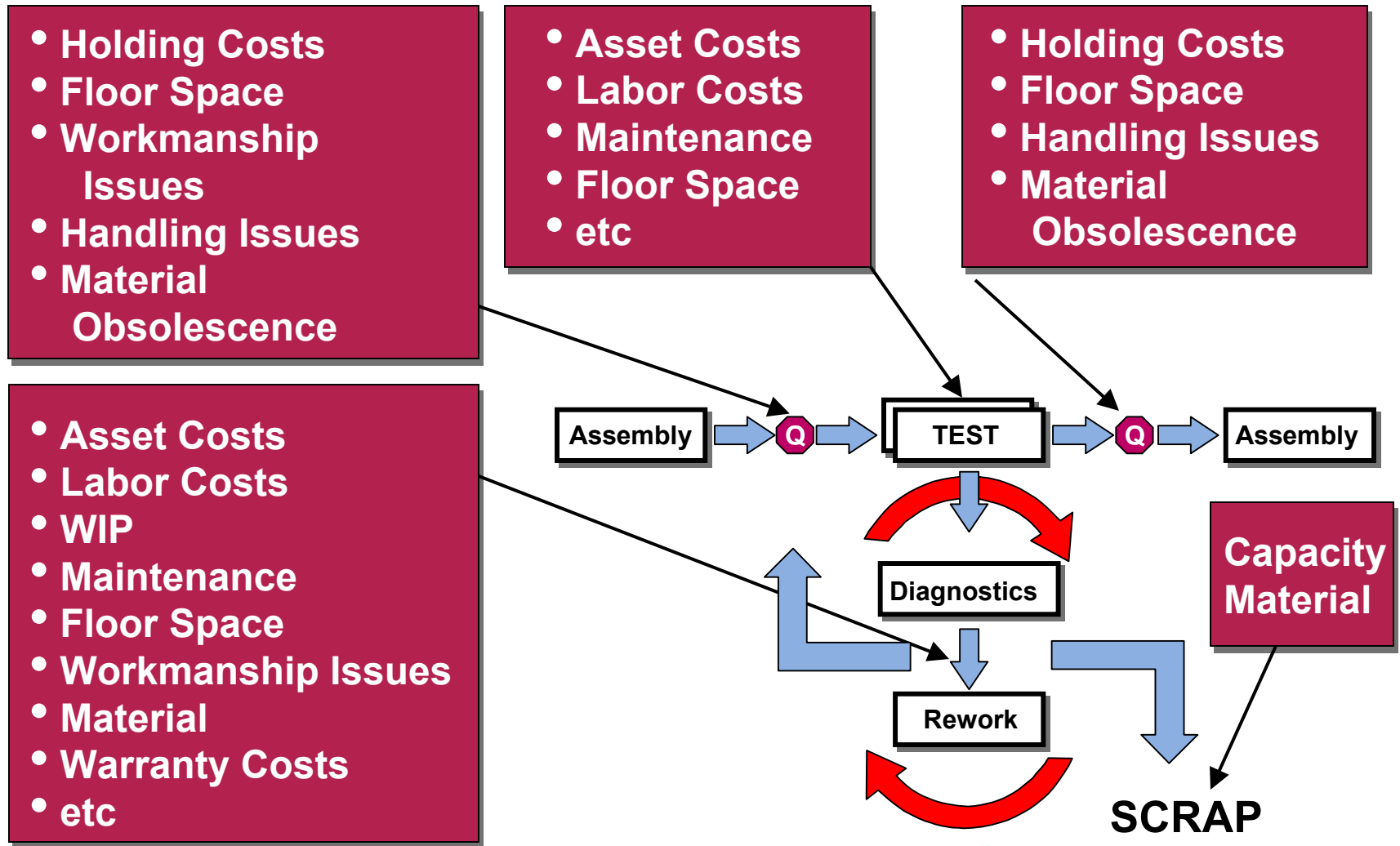
- Good will cost
- Replacement cost
- Cost of diagnostics
- Cost of same design defect in next product



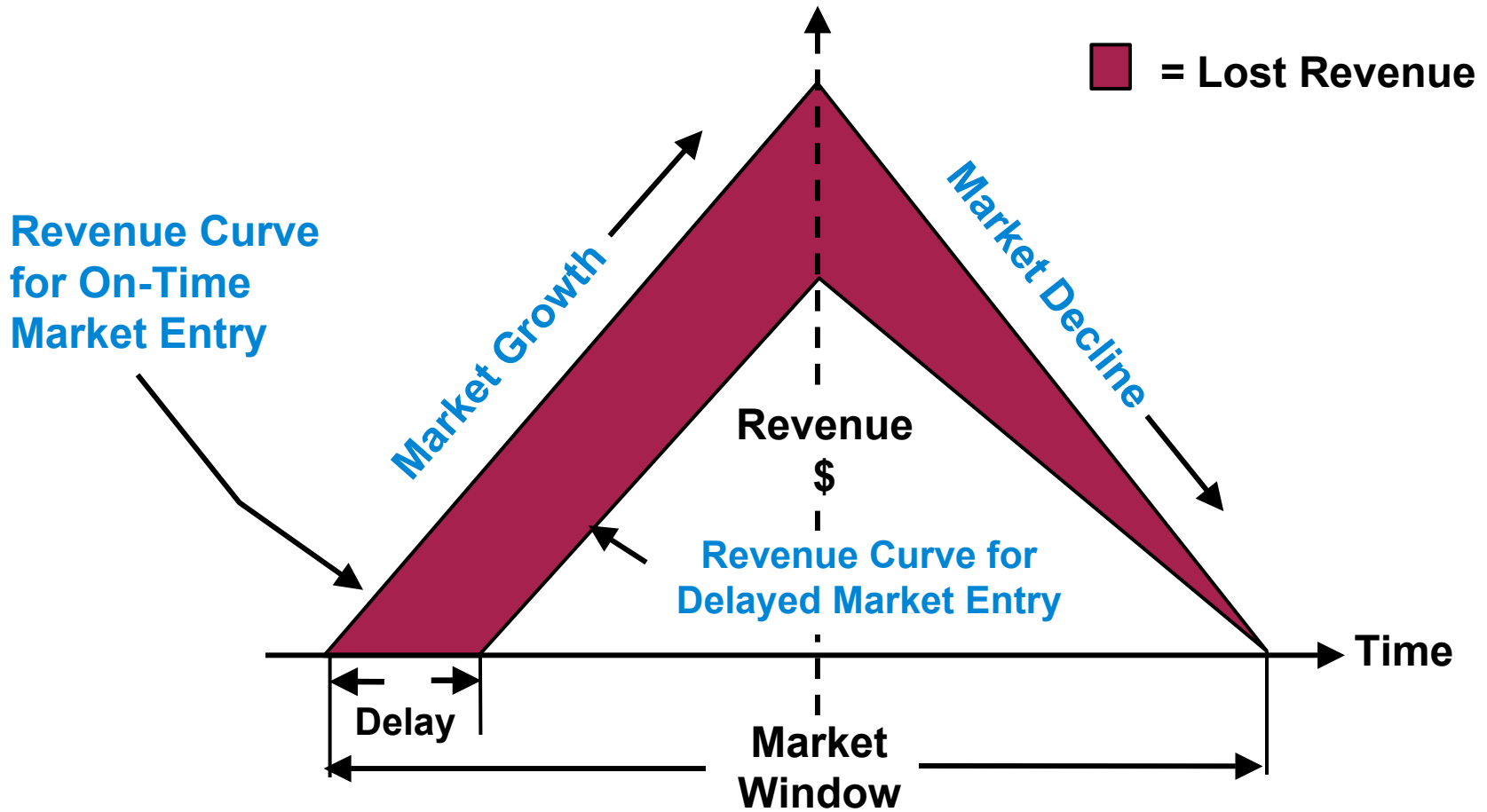
# What Does it Cost to Build a Product?



# How Test Impacts Manufacturing Costs



# The Impact of TTM

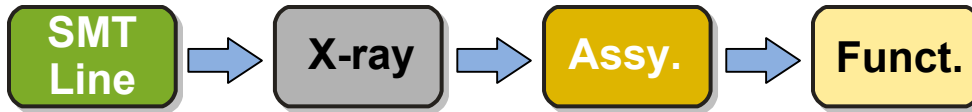


# Sorting Through Test Complexity

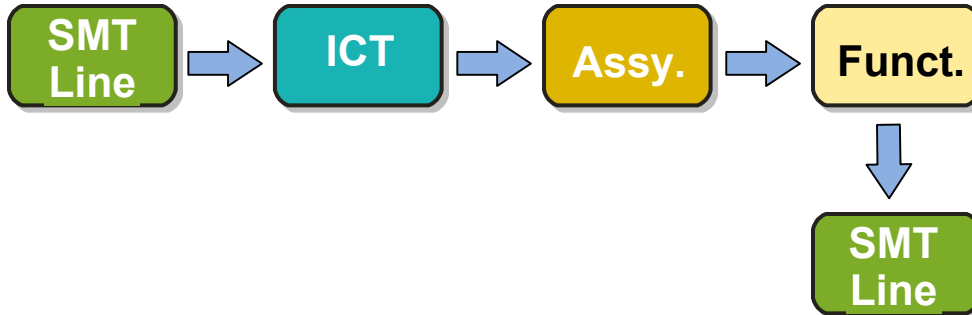
## Scenario 1



## Scenario 2



## Scenario 3



## Business Considerations

- Cost, Markets, Growth Technology
- Product Life Cycle
- Design
- Inventory/WIP
- Volume
- Production Rate
- Globalization
- Return Rate
- Components
- Complexity
- Utilization
- Fault Coverage
- Quality, Yield, SPC
- Resources, Outsourcing
- etc.....



# Let's Look at an Example

## Situation:

- **7,000 Boards/Per Month**
- **Cycle Time = 10 Days**
- **WIP = 12,500 Boards**
- **Overall Pristine Yield = 74%**
- **Lower Level Assy. Includes SMT & Thru-hole Processes w/ Environmental Stress Test of 6 Hours/22 Cycles, 82% ICT Yield**
- **Final Assembly includes two Functional Tests w/94% & 97% Yield, respectively**
- **Customer returns = .2%**



# Let's Look at an Example - Continued -

## Lower Level Assembly

### Areas of Concern

- High number of solder-related defects
- High levels of WIP (9000 boards)
- Long delay time between board assembly and test
- High levels of material failures
- Failures can not be traced back to root cause

### Solution Set

- Implement a test solution that has the highest effectiveness in solder related defects (X-Ray)
- Remove areas of WIP by re-aligning layout
- Develop Root Cause analysis process including material failures





# Let's Look at an Example - Continued -

## Final Assembly

### Areas of Concern

- High levels of WIP (3,500 boards)
- Long delay times between assembly and test
- High levels of material failures
- Long diagnostic times (2 hours average)

### Solution Set

- Remove areas of WIP by re-aligning layout
- Implement process for real time feedback linked with diagnostic and repair process
- Develop Root Cause analysis process including material failures
- Implemented automated diagnostic software



# Let's Look at an Example - Continued -

## *Financial Impact*

- Diagnostic and repair savings from more effective test
- Elimination of scrapping good material
- Elimination of warranty returns from more effective test
- 15% more capacity and reduction in WIP because of improved yields
- Double the through-put and elimination of redundant test processes

=

**Savings:**  
**\$179,913 a Month**  
**or**  
**\$2,158,956 a Year**



# Key Concepts

- **Primary test parameters are:**
  - Effectiveness
  - Fault Spectrum
- **The effects of test vary based on the manufacturing environment (volume, quality, time) and function (R&D, production manufacturing, warranty).**
- **Typical manufacturing costs are:**
  - 80-85% material, 7-10% overhead, 5-8% labor, 2-3% test
- **An optimized test strategy can yield financial performance improvement in the following areas:**
  - lower diagnostic & repair costs
  - warranty returns reduced or eliminated
  - reduced scrap
  - increased plant capacity
  - increased throughput



# Agilent Resources

**For Further Information on Agilent's Enterprise Business Consulting Services including :**

- **Manufacturing and Test Process Development Services**
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