Implementation of DFMA in VAVE Methodology at SANMINA-SCI's Mechanical Systems Division

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2012 INTERNATIONAL FORUM ON DFMA

BDI
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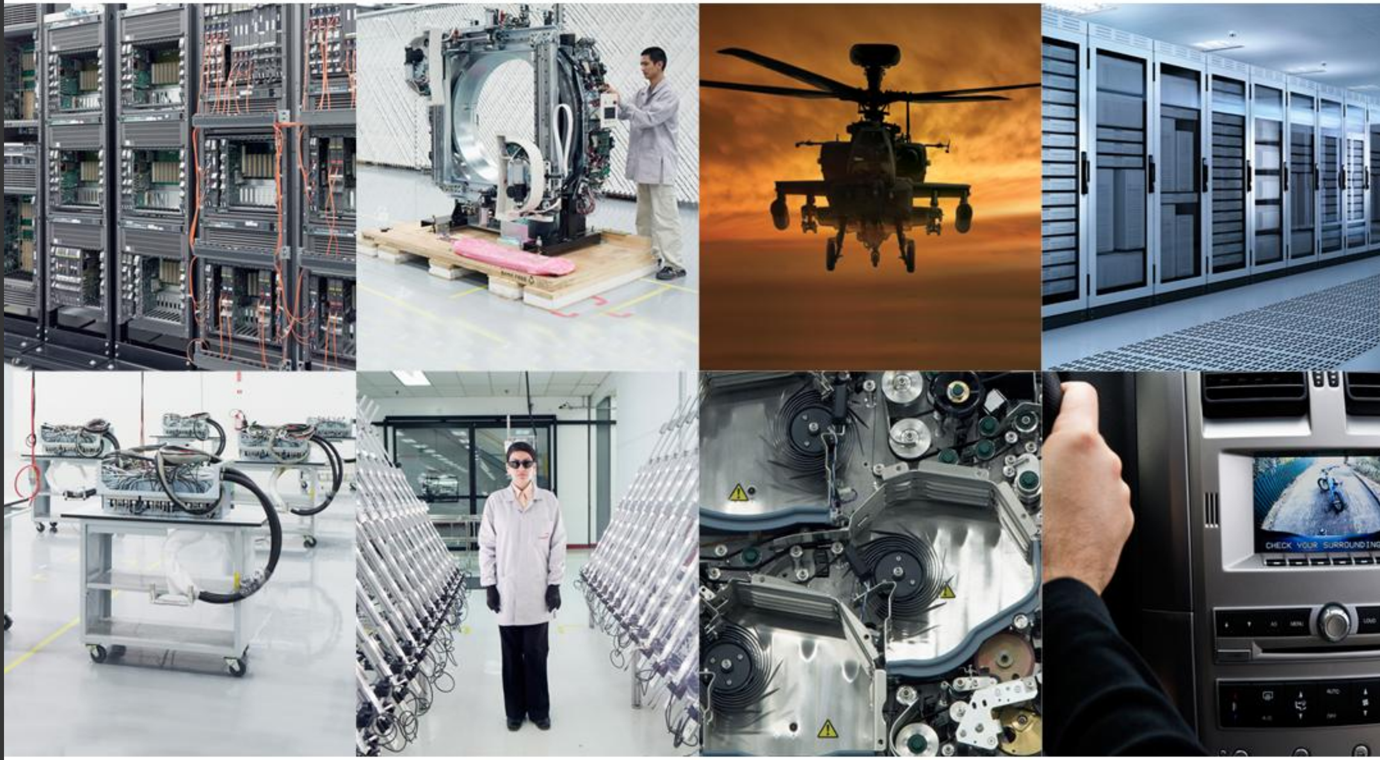

Presented by Mike Bogosian, Sanmina-SCI Derry NH
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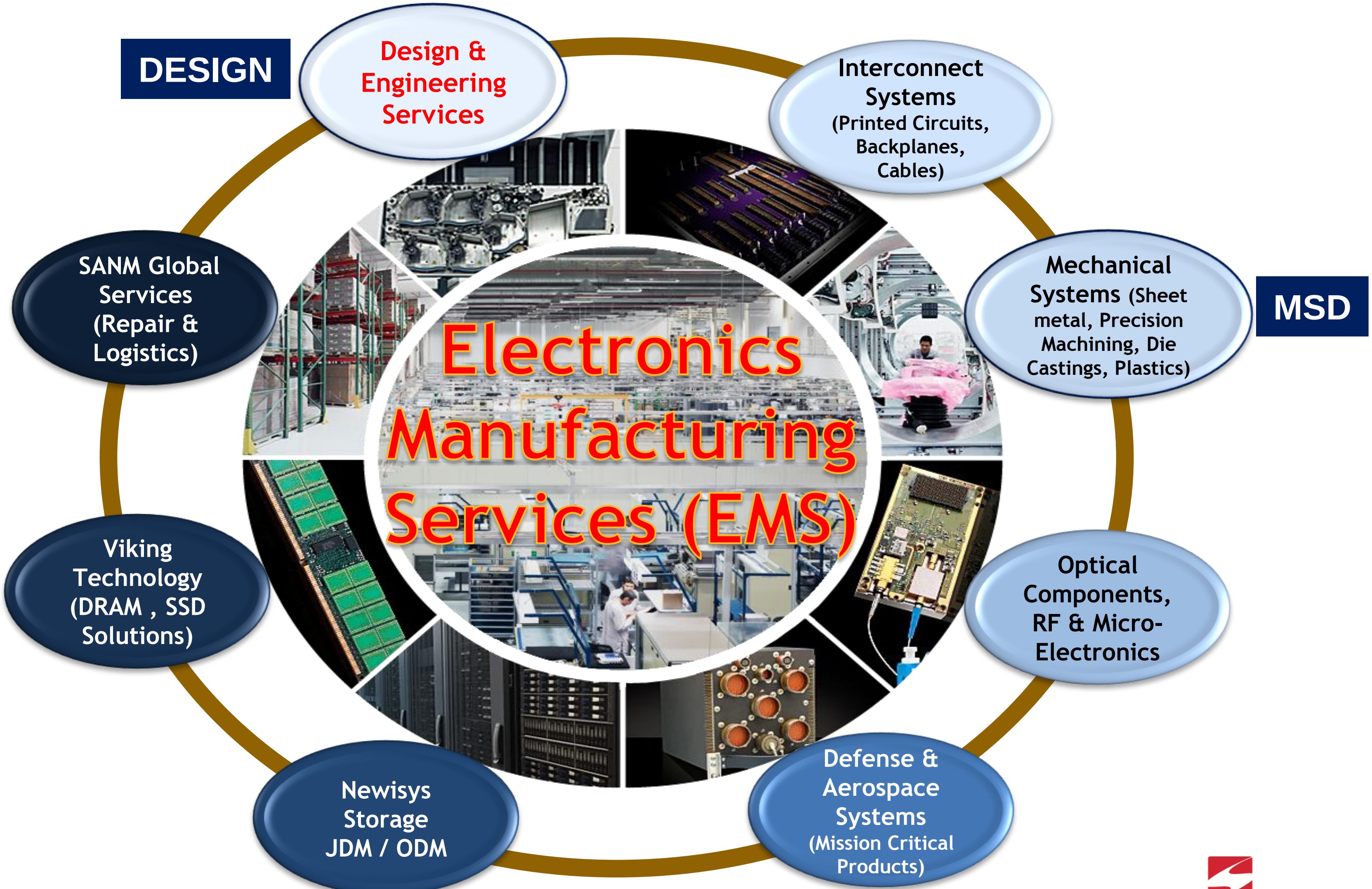
Sanmina-SCI Company Profile

- Founded in 1980, San Jose CA
- Global footprint – 70+ facilities in 24 countries
- ~45,000 employees
- $6.6B in Revenue, FY 2011
- System manufacturing solutions for key Infrastructure markets
  - Technologies, products, design and logistics services
- Diversified, strong customer base (Fortune 100)
- Operations Excellence & Quality: One I.T. System (Oracle) Mature, Effective Manufacturing & Quality Systems

Argentina • Australia • Brazil • Canada • Czech • China • Colombia • England • Finland • Germany
Hungary • India • Indonesia • Ireland • Israel • Japan • Malaysia • Mexico • Scotland
Singapore • South Africa • Sweden • Thailand • United States

Sanmina-SCI Focus: Technologies, Products & Services

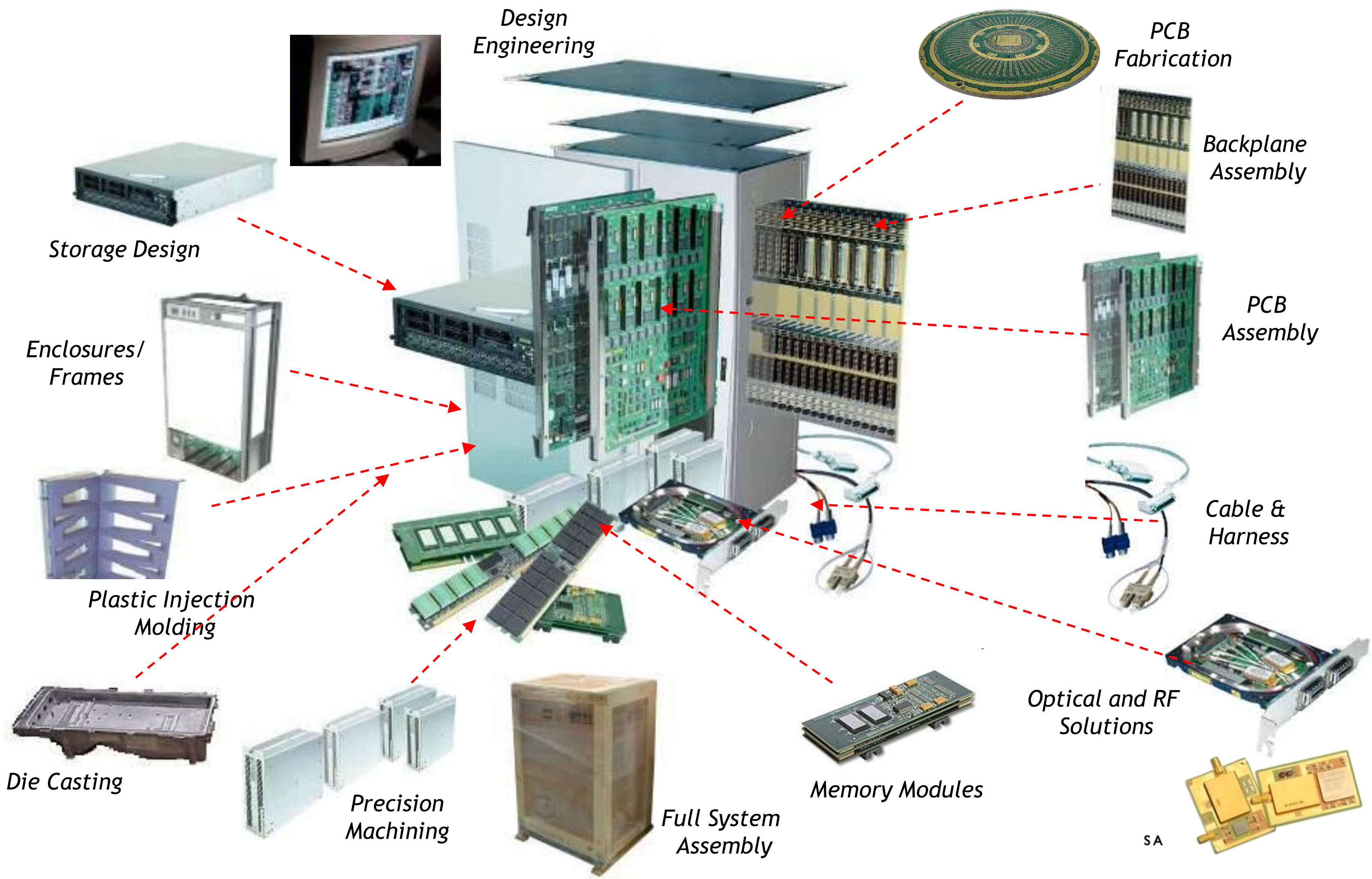
Collaborative Design and Engineering → Interconnect → Mechanical Systems → Optical , RF Components → Manufacturing Services (EMS) → Products and Services → Logistics and Direct Order Fulfillment



Best-In-Class Products & Services

Sanmina-SCI ‘End-to-End’ Integrated Services: from Components to Systems

Concept Phase → Design Phase → Prototype Phase → Mfg. Launch Phase → Production Phase → End-of-Life Phase



Scope of Mechanical Systems Division

Metal Enclosures

Plastic Injection Molding

Aluminum Die Castings

Precision Machining

Precision Welded Frames

- Design & Value Engineering - Structural, Thermal, Power, Regulatory
- Mechatronics - Complex System Integration & Test, Clean Room Facilities
- Standard Solutions - Racks, Cabinets, Cooling Solutions
- Products for Networking & Telecommunications, Computing & Storage, Industrial, Semiconductor & Cleantech, Medical, Multimedia
- Configure to Order (CTO) / Build to Order (BTO)

Complex System Integration

Global Engineering Locations

OPTICAL, RF, MICROELECT.
Turnkey System Design
Module & Test engineering
Kanata, Ottawa

MECHANICAL DESIGN
PRODUCT DEVELOPMENT
Calgary, Canada

SYSTEMS DESIGN (HW/SW)
INTERCONNECT TECH.
PCB, BP, SI - HIGH SPEED
ENCLOSURES, VAVE
FA/SI/Thermal Labs
San Jose & Fremont CA

VIKING TECHNOLOGIES
Memory Modular Solutions
Foothill Ranch CA

NEWISYS STORAGE
Turnkey System Design
Co Springs CO

OPTICAL COMMUNICATIONS
Turnkey System Design
Carrollton TX

MEDICAL SYSTEMS,
DEFENSE & AEROSPACE
Turnkey System Design
Validation Test Labs
Huntsville AL

TEST ENGINEERING
Guadalajara, MEXICO

AMERICAS

EUROPE, ASIA

Technical Sales &
Product Dev Support
Paris, France; UK

CABLES ENGINEERING
Port Glasgow, Scotland

MEDICAL & INDUSTRIAL
Mechanical Design
Ma'alot, Israel

NPI ENGINEERING
TEST DEVELOPMENT
Yasu, Japan

MECHANICAL DESIGN
Shenzhen, China

SYSTEM DESIGN
Reliability Lab
Singapore

SYSTEM DESIGN HW/SW
PCB layout, Test Dev.
Module engineering
Chennai, India

14 Design Centers in 8 countries
23 NPI locations in 13 countries
450+ dedicated design and NPI engineers
1,500+ technical manufacturing resources.

Canada • China • Finland • Germany • India • Ireland • Israel
Japan • Mexico • Scotland • Singapore • Sweden • United States

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Design & Value Engineering

Early Involvement
Role of DFMA

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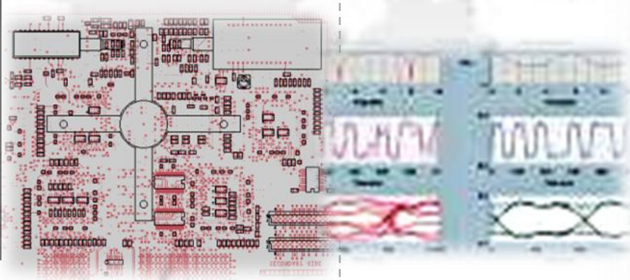
Early Engineering Involvement in Customer's Product Life Cycle

Product Design, Development	Prototyping, Debug, Validation	New Product Introduction	Volume Manufacturing	EOL, Sustaining Engineering



Quick Turn, NPI Services Close to Customer

- Product Design
- Early Involvement, DFx
- Technology & Components
- Value Engineering (DFMA)
- Test System Design

Global, "Best Cost" Manufacturing

- Volume Manufacturing launch
- Transfer to "Best Cost" Facility
- Global Supply Management
- Ongoing Value Engineering
- Test Automation

Logistics & Repair Services

- Build / Configure to Order
- Direct Order Fulfillment
- Repair, Refurbishment
- Spares, Hubs
- Sustaining Engineering

Early Engineering Involvement in the Product Life Cycle

Early Engineering Involvement

Concept Phase
- Design Architecture Evaluation
- DFx Analysis
- Component & Vendor Selection
- Process technology assessment/gap analysis
- End-to-end test strategy assessment
- Supply Chain Strategy
- Value Engineering
- Risk Analysis

Design Phase
- Mechanical Design
- Electrical Design
- CAD Layout
- DFx / DFMA / VAVE
- Modeling/Analysis
  - -Thermal
  - -Structural
  - -EMI/EMC
  - -Signal Integrity
  - -Reliability
- Process & Test Technology
- Engineering Documentation
- Supply chain analysis

Prototype Phase
- Quickturn NPI Manufacturing.
- DFx Feedback
- First Article eval
- Test Development
- Design Validation Testing, Interop
- Regulatory & Compliance Test
- Design/BOM Release
- Manufacturing Readiness – supply chain, process, test

Pre-Prodn Mfg Launch Phase
- Process Optimization
- Manufacturing Documentation
- Test Automation
- DFx Enhancements
- Value Engineering
- Ramp/Yield Management
- ECO Management
- Supply Chain
- Product transfer to “best” cost location

Sustaining Phase
- Customer Support
- Sparing
- VAVE
- Failure Analysis
- Corrective Actions
- RMA Management
- Geographic Transfer
- Components Engineering/LCM
- Order Management
- Reverse Logistics

End-of-Life Phase
- Warranty/Repair
- Long-term Sparing / Inventory mgmt
- Mfg Infrastructure Maintenance
- Last Time Buys
- Lessons Learnt Analysis
- Recycling

Design & New Product Introduction

Gateway to Volume Manufacturing

Transfer to Lower-cost Regions

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System level DFX Overview

DFM for PCB & Assembly
PCB Design Considerations
SMT Design Considerations
Design Considerations for Lead Free, WEEE

DFM for Microelectronics
Design Considerations for Eutectic Die Attach
Design Considerations for Components Attach
Design Considerations for Wire Bonding

Design for RF
Transmission Line Design & Termination
SMT Pad Design for RF Components
Design Considerations for EMI

Design for Mechanical Assembly
Design Considerations for Enclosures
Design Considerations for Inter-Wiring
Assembly/Disassembly Guidelines

Design for Supply Chain
Supply Chain Total Cost of Ownership
Alternate Sourcing Strategy

DFT for Structural Test
ICT Electrical & Mechanical Guidelines
Boundary Scan Testing Requirements
Limited Access Test Strategy

DFT For Functional Test
Built-in Self Test (BIST) Guidelines
Board Partitioning of Functional Blocks
Loopback Capabilities & Signals Access

Design for Photonics
Optical Mechanical Assembly Design
Optical Components Design Guidelines
Optical Design for Test

Design for Reliability
Reliability Considerations for O/E Devices
FMECA, HALT & HASS Requirements
Failure Rate Prediction Analysis Methods

Design for Maintainability
Design for Sustainability & Installability
Design for Repairabiilty & Serviceability

Design for Cost / Value Add Value Engineering

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Value Engineering Approach

Objective: Isolate areas of product weaknesses and Improvement opportunities as part of early involvement:

- **Analyze cost drivers: 80/20 rule dictates**
- **Interconnect complexity: multiple circuits, system interconnect layers**
- **Study ease of assembly**
- **Understand applied test practices**
- **Fabrication options: punch and form, cast, injection mold**
- **Apply BDI DFMA thought process**
- **Consider ways to streamline the supply chain for large complex fabrications – frame VI opportunities**

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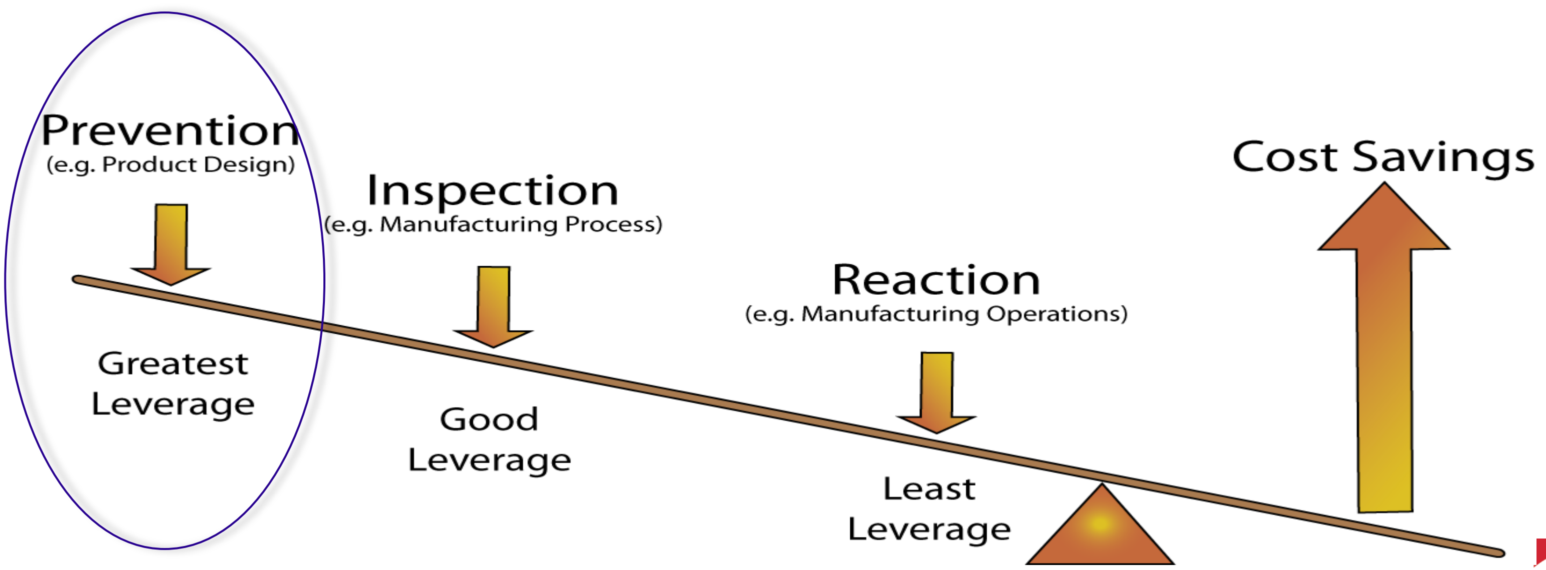
Timing of DFX Inputs in Product Lifecycle

***Early Involvement** by Test/Process Engineering in the product design cycle is critical to reducing total product costs.*

Concept Phase → Design Phase → Prototype Phase → NPI Phase → Volume Phase → End-of-Life Phase

Initial Interim DFX DFX

DFX DFX Feedback Enhancements



Cost of Quality Lever

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DFMA Recommended Process
Early Involvement

Product Concept ← **DFMA**

↓

Feasibility Demonstration Models

↓

Engineering Prototype ← **DFMA**

↓

Verification Prototype ← **DFMA**

↓

Manufacturing Prototype

↓

Production Instrument

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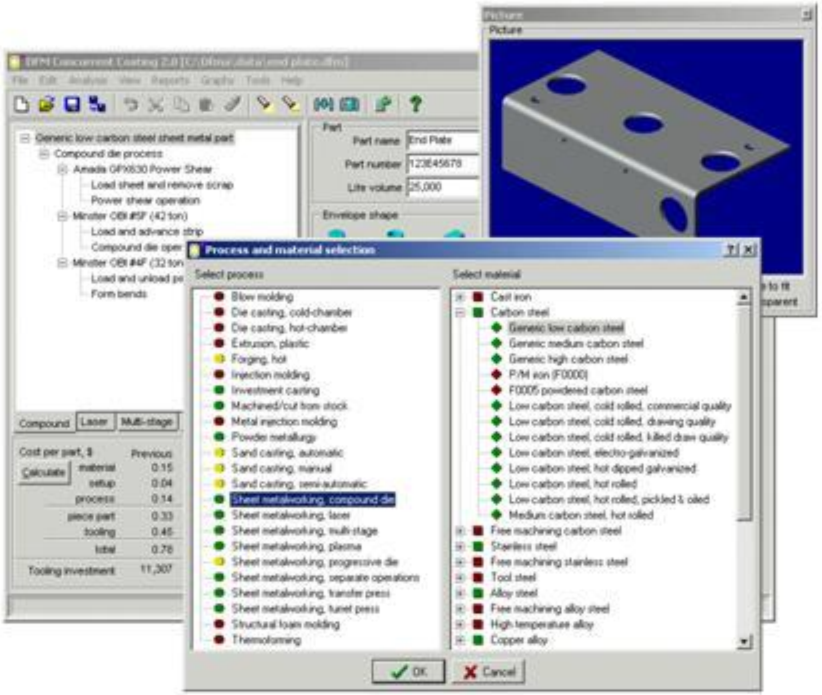
Boothroyd Dewhurst DFMA Process

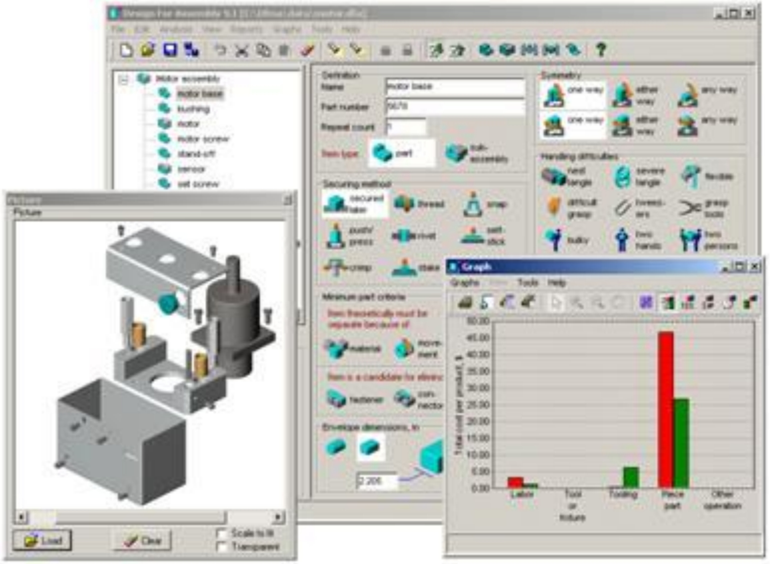
DFMA Software uses a question-and-answer approach to help determine the most cost-effective and efficient

- **assembly method,**
- **manufacturing process, and**
- **materials for a particular part or product.**

Design for Manufacture: Early Cost Estimating



Design For Assembly: Product Simplification



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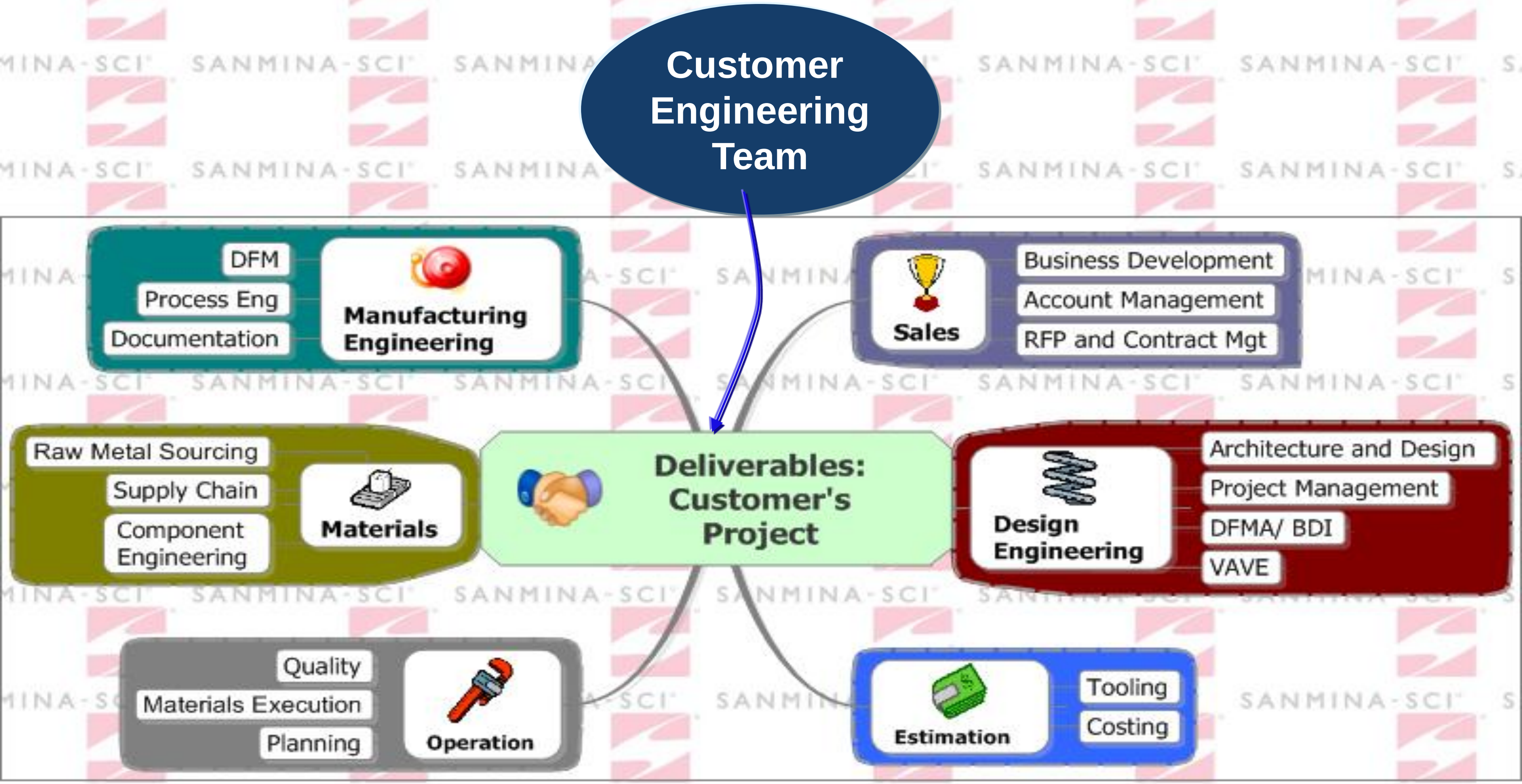
Sanmina-SCI Engineering Ecosystem for DFMA / VAVE

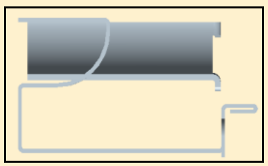


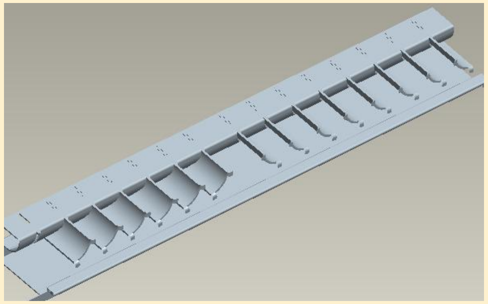
Design & VAVE team in Fremont CA to support customers & manufacturing

Example: Redesign of Cable Management

Existing Design

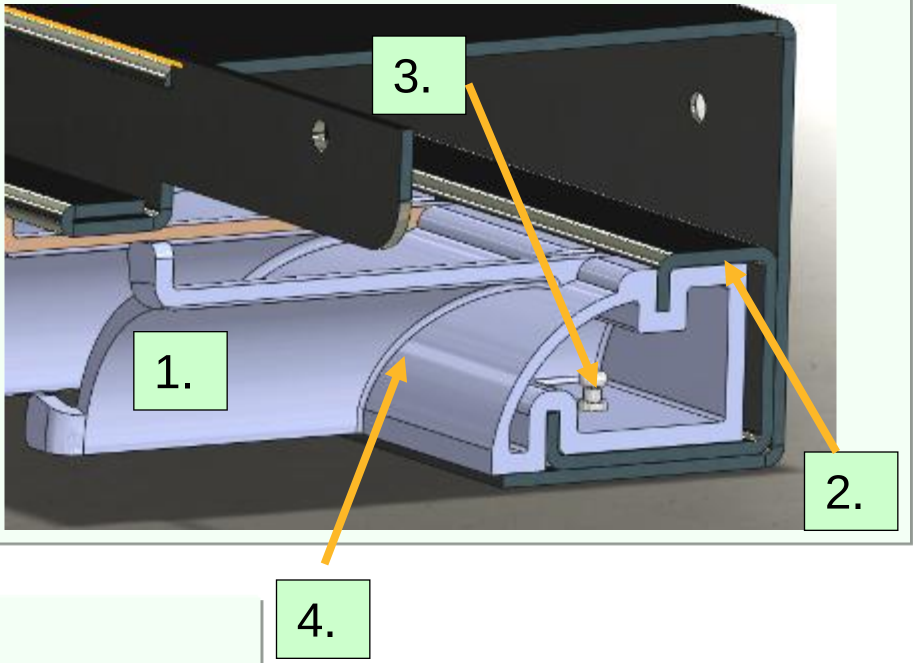
1. Welded Sheet metal part
2. High weight due to steel construction
3. Requires assembly/ Welding fixtures





Proposed changes

1. Create slide-in plastic inserts
2. Group inserts onto Channel\
3. Rivet to main support bracket
4. Optimize strength using molded-in gussets



Benefits:

- **Cable Management System - up to 60% Cost Reduction potential (confirmed thru BDI Analysis), by eliminating welding & fixtures, reducing weight , and improving assembly processes.**

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DFMA ANALYSIS – Material selection: Cast Urethane or Injection Molded?

Design for Assembly: Analysis Totals Comparison

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Thursday, July 22, 2010 3:24 PM
410-5440-003_Alternate

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Product: proto cafe, inj molding

Per product data

	proto cafe	inj molding
Entries (including repeats)	21	21
Number of different entries	8	8
Total assembly labor time, s	116.78	116.78
Weight, lb	4.54	4.54

Per product costs

Labor cost, $	2.21	2.21
Other operation cost, $	0.00	0.00
Manuf. piece part cost, $	30.31	42.37
Total cost without tooling, $	32.52	44.59
Assy. tool or fixture cost, $	0.00	0.00
Manuf. tooling cost, $	28.26	6.64
Total cost, $	60.78	51.23

Production data

Product life volume	2,000	2,000
Overall plant efficiency, %	85.00	85.00
Labor rate, $/hr	58.00	58.00

Production life costs

Labor cost, $	4,427	4,427
Other operation cost, $	0	0
Manuf. piece part cost, $	60,615	84,749
Total cost without tooling, $	65,042	89,176
Assy. tool or fixture cost, $	0	0
Manuf. tooling cost, $	56,521	13,284
Total cost, $	121,564	102,461

DFA Index

Theoretical minimum number of items	2	1
DFA Index	5.0	2.5

CAST URETHANE VS.

INJECTION MOLDING:

CAST URETHANE MOLDING WILL WORK FOR LOW QUANTITY PROTOTYPE RUNS, BUT INJECTION MOLDING SUPPLIER HAS THE MOST COMPETITIVE PRICING / OVERALL LIFETIME COST.

(COMPARATIVE / BUDGETARY CALCS ONLY)

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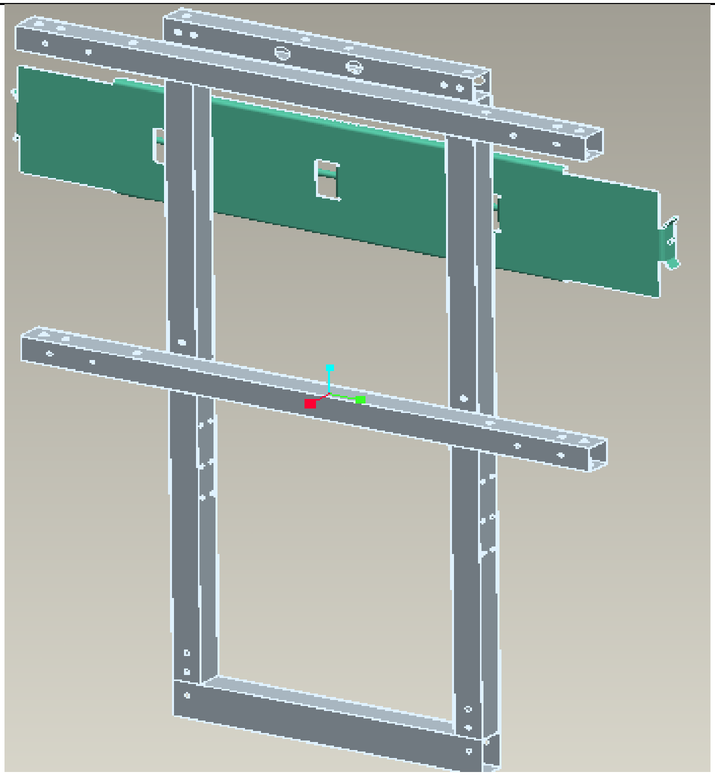
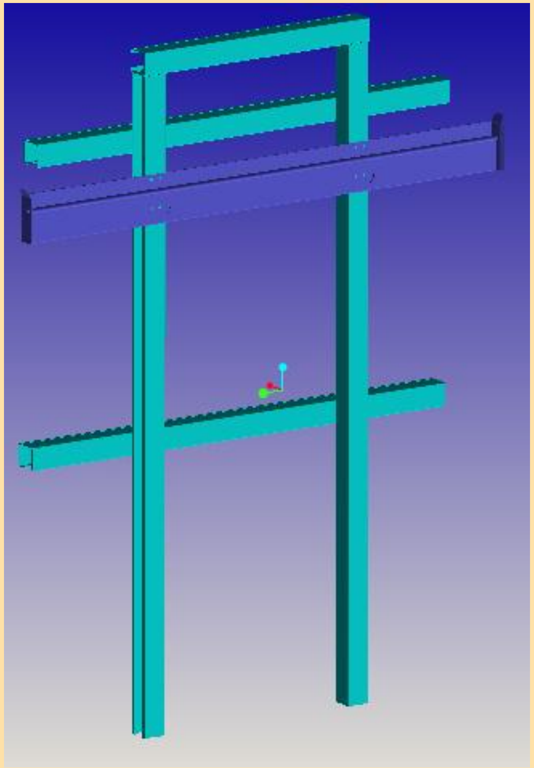
Example: Tube Frame to Sheet Metal Design

Existing Design	New Design





New Design reduces part count, remove welding and post finishing processes -- New Design is a riveted C-Channel Assembly using pre-plated CRS

BDI Analysis estimates 58% cost savings

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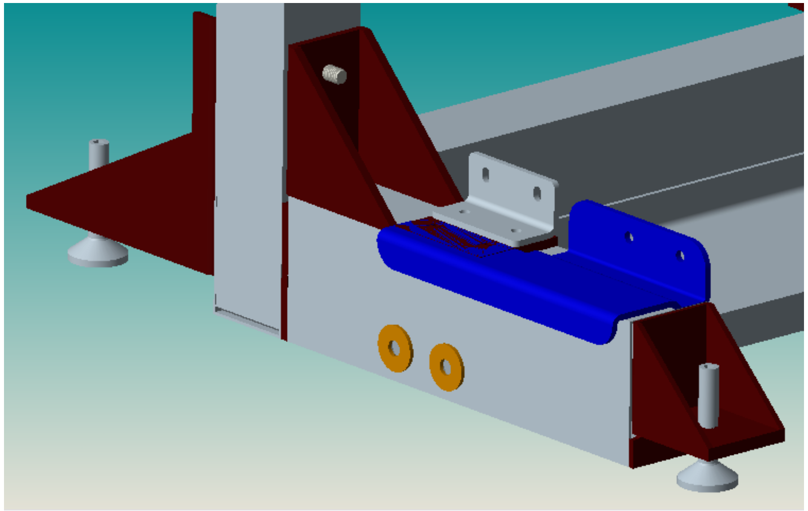
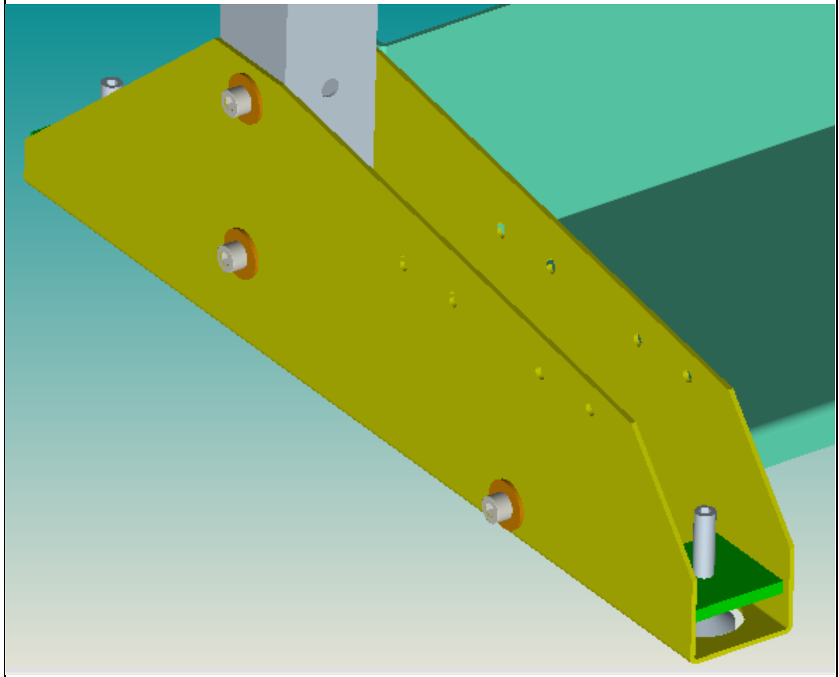
Example: Pedestal Foot Re-design

Existing Design	New Design
	

- Redesign foot combines front and back features into on left/right foot
- Part reduction from 11 parts to 5 parts and eliminates other brackets
- Hardware reduction from 5 bolts to 3 bolts per foot
- BDI Analysis estimates 37% cost savings

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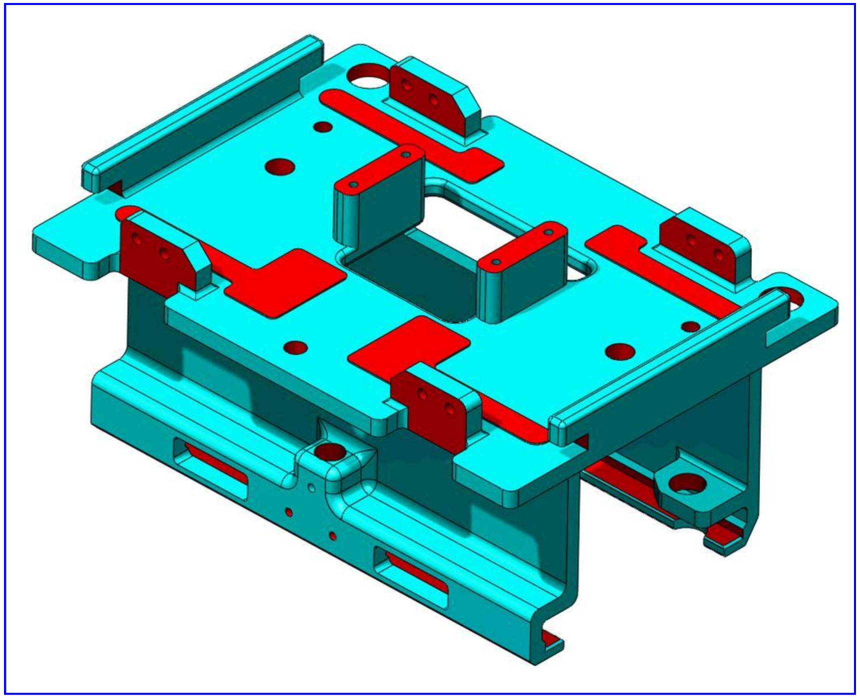
Example: Investment casting vs sheetmetal

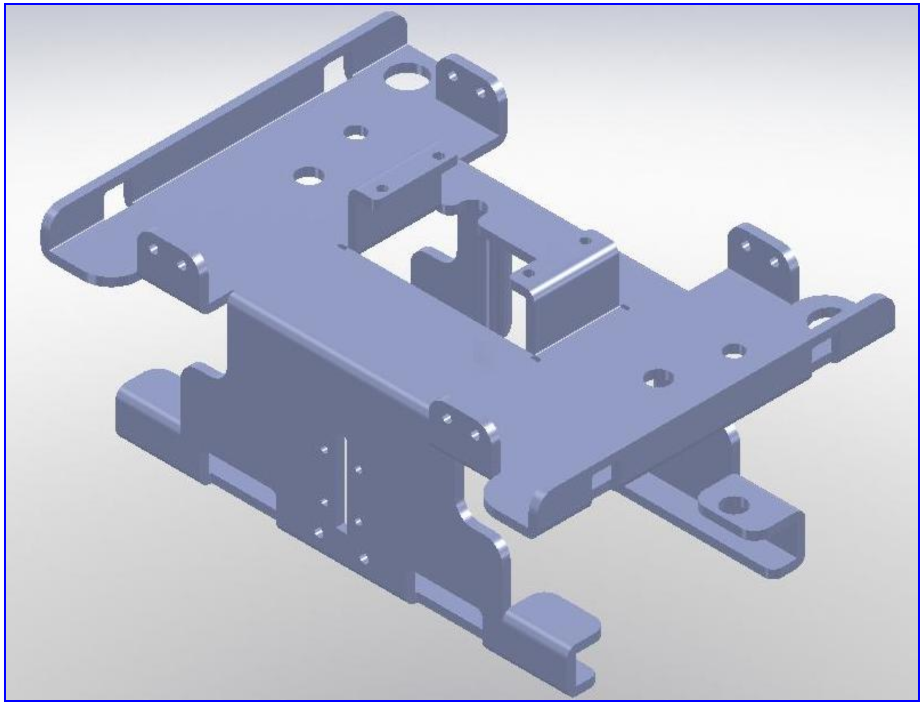
Investment Cast Part

Sheetmetal part

Part Number:



New Part Number



15%-20% piece part savings going with sheet metal vs. cast
Budgetary Tooling Cost: $20K-$25K for Cast vs. $500-$750 for Sheet metal

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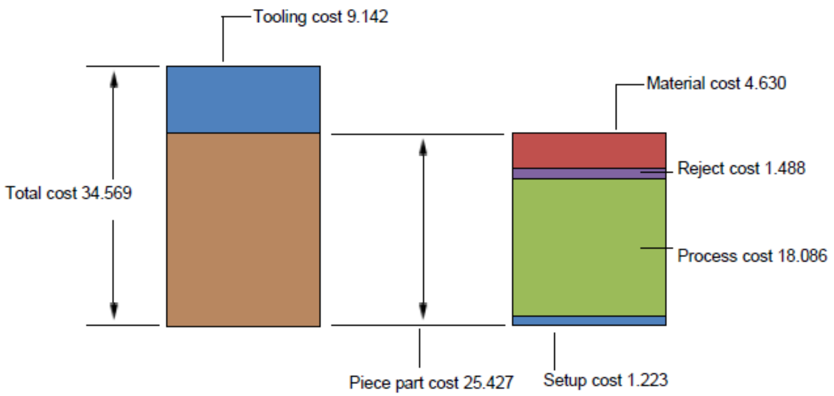
Example (cont'd) - DFC Analysis

Investment Cast Part

Part Number:

Product life volume	1,800
Batch size	225
Total cost, $	34.57
Piece part cost, $	25.43
Initial tooling investment, $	16,456

The chart shows a breakdown of the costs, $

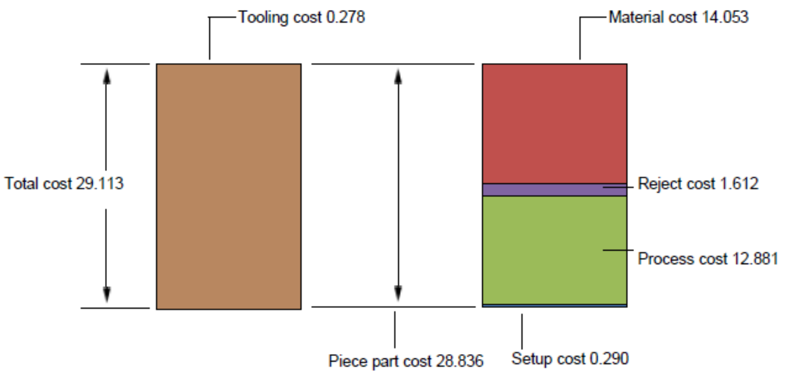


Sheetmetal Part

New Part Number:

Product life volume	1,800
Batch size	1,740
Total cost, $	29.11
Piece part cost, $	28.84
Initial tooling investment, $	500

The chart shows a breakdown of the costs, $



Note: Threaded inserts and labor to install cost not considered in this analysis

Value Engineering Example:
Original vs. Unified one piece redesign

Per product data

	Original	Unified Chassis
Entries (including repeats)	6	1
Number of different entries	4	1
Total assembly labor time, s	20.70	3.45
Weight, lb	10.24	* 0.00

Note: Weight not given for some items. Total weight may be incomplete.

Per product costs

Labor cost, $	0.20	0.03
Other operation cost, $	0.00	0.00
Manuf. piece part cost, $	33.61	12.92
Total cost without tooling, $	33.81	12.95
Assy. tool or fixture cost, $	0.00	0.00
Manuf. tooling cost, $	0.00	0.00
Total cost, $	**33.81**	**12.95**

Production data

Product life volume	10,000	10,000
Overall plant efficiency, %	85.00	85.00
Labor rate, $/hr	30.00	30.00

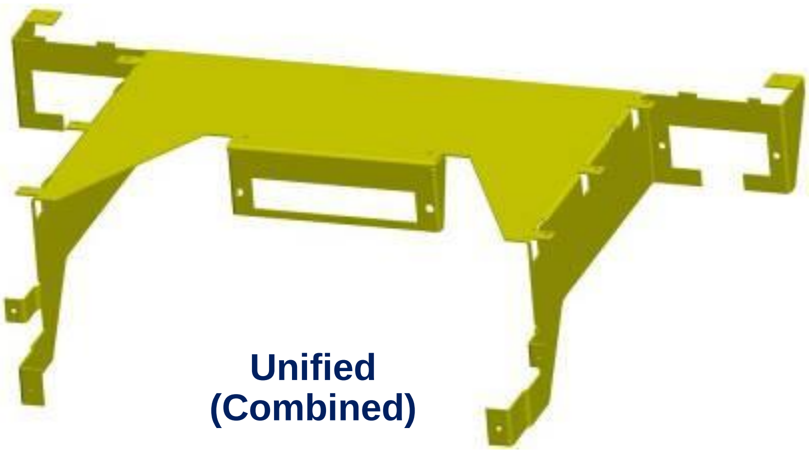
Production life costs

Labor cost, $	2,029	338
Other operation cost, $	0	0
Manuf. piece part cost, $	336,071	129,210
Total cost without tooling, $	338,100	129,548
Assy. tool or fixture cost, $	0	0
Manuf. tooling cost, $	0	0
Total cost, $	**338,100**	**129,548**

DFA Index

Theoretical minimum number of items	0	0
DFA Index	0.0	0.0

Original



Unified (Combined)

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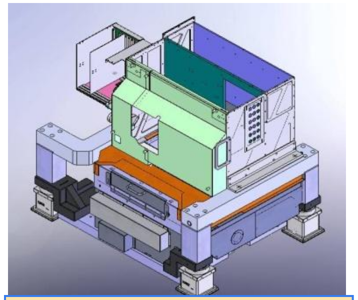
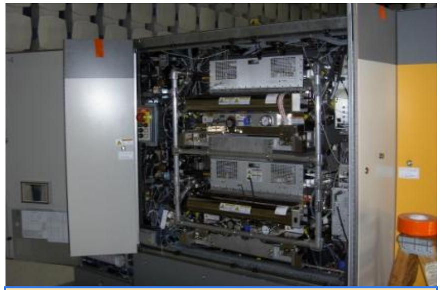
Examples of Electromechanical Products with Design/VAVE content

Power Distribution Cabinet
Semi-conductor



Vibration Isolation Metrology Tool

Chemical Recycling



Semiconductor: Lithography Tool

Inverter Cabinet

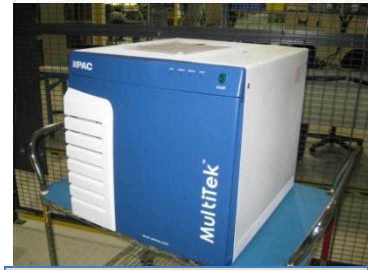
Networking Compact Router

Datacenter Server Rack

Medical Cart

Multimedia Gaming System

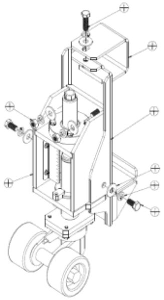
Stack I/F Unit
Fuel cell car



Gas Analyzer
Petroleum industry

Datacom:
Enterprise Switch

Telecom
Wireless Base Station



Tooling - SemiC equipment

Concentrated Solar
Service Module

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Summary

Sanmina-SCI's Mechanical Systems Division has successfully implemented the BDI-based DFMA process into its VAVE methodology - for new product designs as well as "build to print" existing designs.

Cost savings are generally higher when an Early Involvement (EI-DFMA) approach is accepted by the OEM design authority

Successful implementation requires proactive cross-functional team effort between customer engineering, design, manufacturing engineering, estimation and supply chain.

Improvement opportunities as part of early involvement typically cover:

- **Interconnect complexity: multiple circuits, system interconnect layers, ease of assembly, test practices, fabrication options, and supply chain optimization**

Thank You!