Design Methodologies & Manufacturing Processes that Result in Automatic DFMA Improvements

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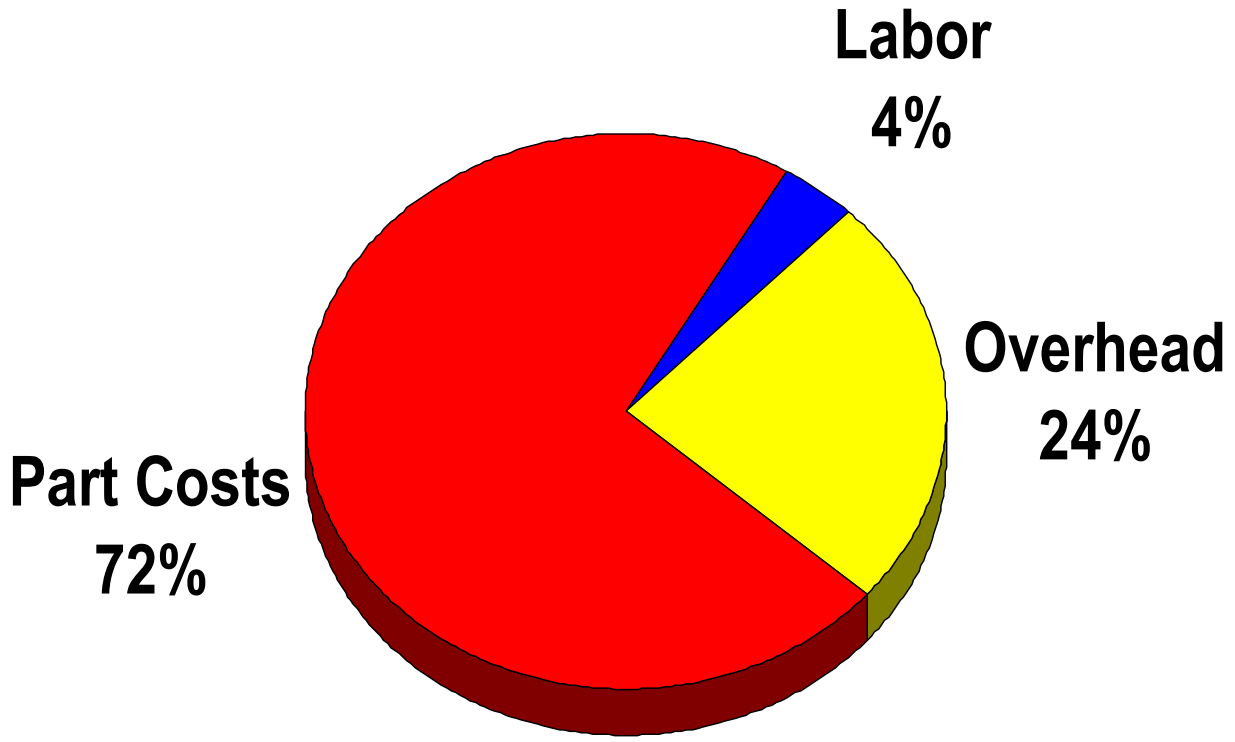
Typical Product Cost Breakdown



Source : The True Cost of Oversea Manufacturing June 2004 N. Dewhurst & D. Meeker

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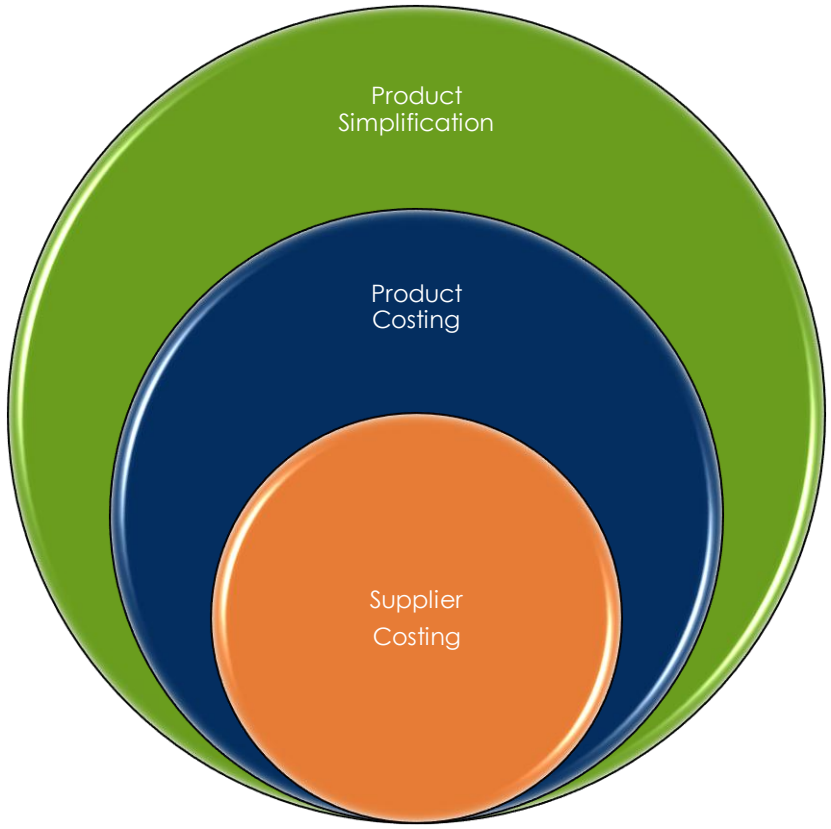


PRODUCT SIMPLIFICATION

Our real time approach to product simplification unlocks the potential for part count reduction within your assemblies

PRODUCT COSTING

Looking at the alternative process and/ or material combinations that may lead to potential piece part cost savings

SUPPLIER COSTING

Using the outputs from our DFMA software to better negotiate price in a real time fashion

The Three main uses of DFMA*

* DFMA Design Decision B&D International Conference June 8th 2016

How do you get from here to there ?

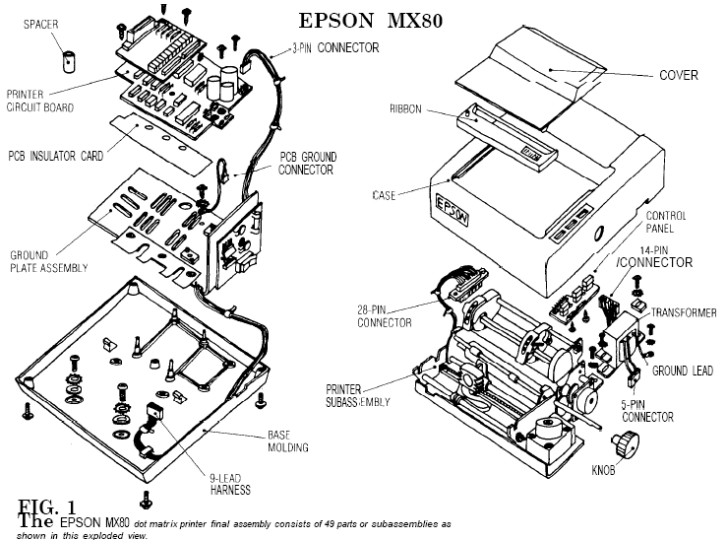


FIG. 1
The EPSON MX80 *dot matrix printer final assembly consists of 49 parts or subassemblies as shown in this exploded view.*

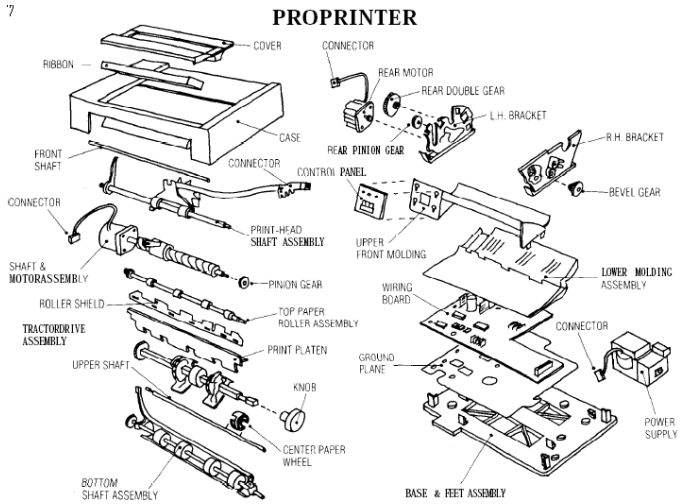
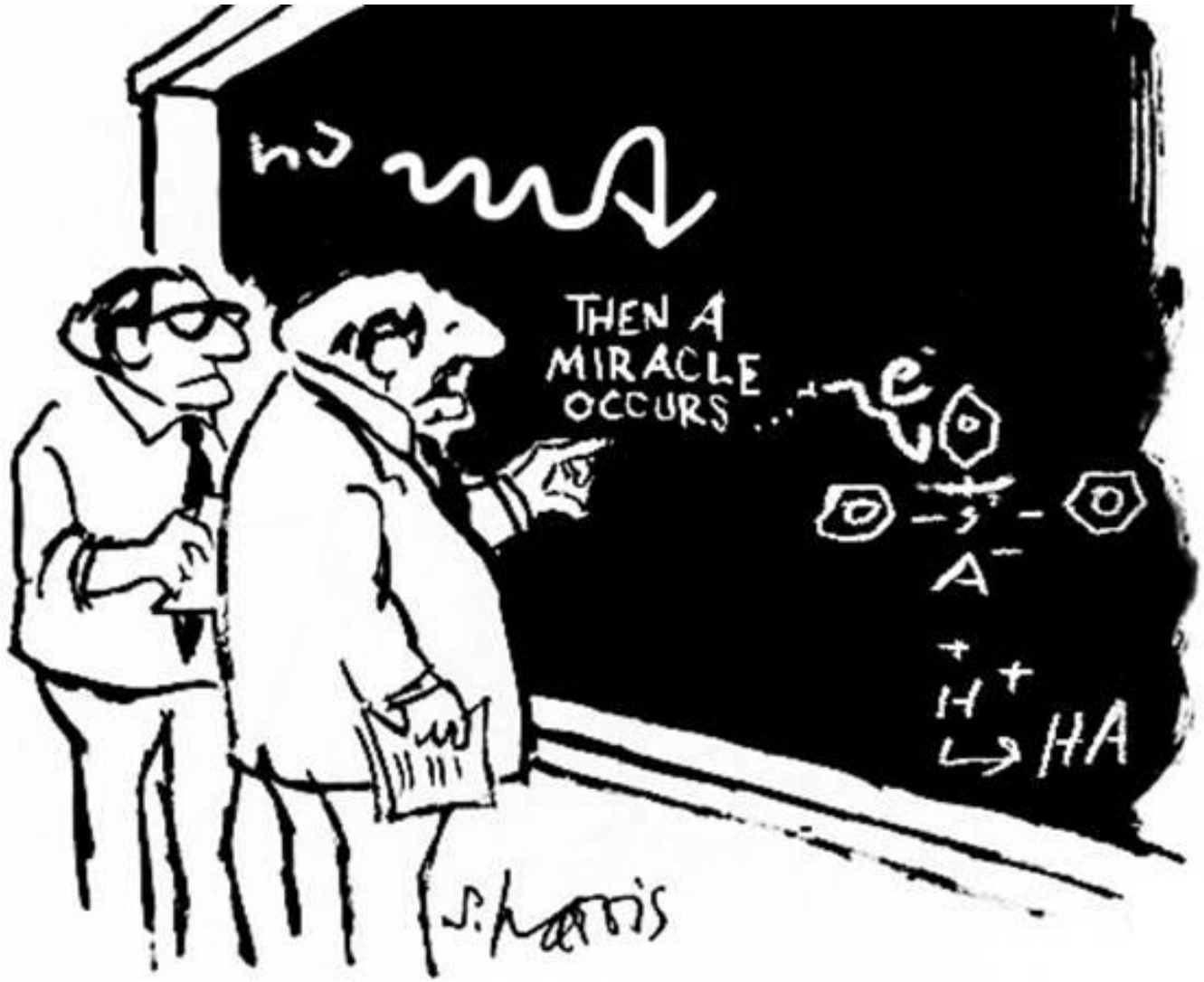


FIG. 5
Exploded view of IBM Proprinter highlights design simplification in this product.

Parts	255
Operations	185

Part	32
Operations	32



"I think you should be more explicit here in step two."

from *What's so Funny about Science?* by Sidney Harris (1977)

Design Methodologies & Manufacturing Processes That Result in Automatic DFMA Results

These processes include but are not limited to:

- Electronic Packaging and Assembly Concept EPAC
- 3D Molded Interconnect Devices and/or 3D Mechatronic Integrated Devices 3D MID
- Electro Magnetic Assembly Bonding EMABOND
- 3D Printing
- Hydroforming
- Stir Welding

Electronic Assembly Packaging Concept EPAC

Part Count, Product Complexity Reduction

A typical electromechanical product secures the ‘good “ parts with:

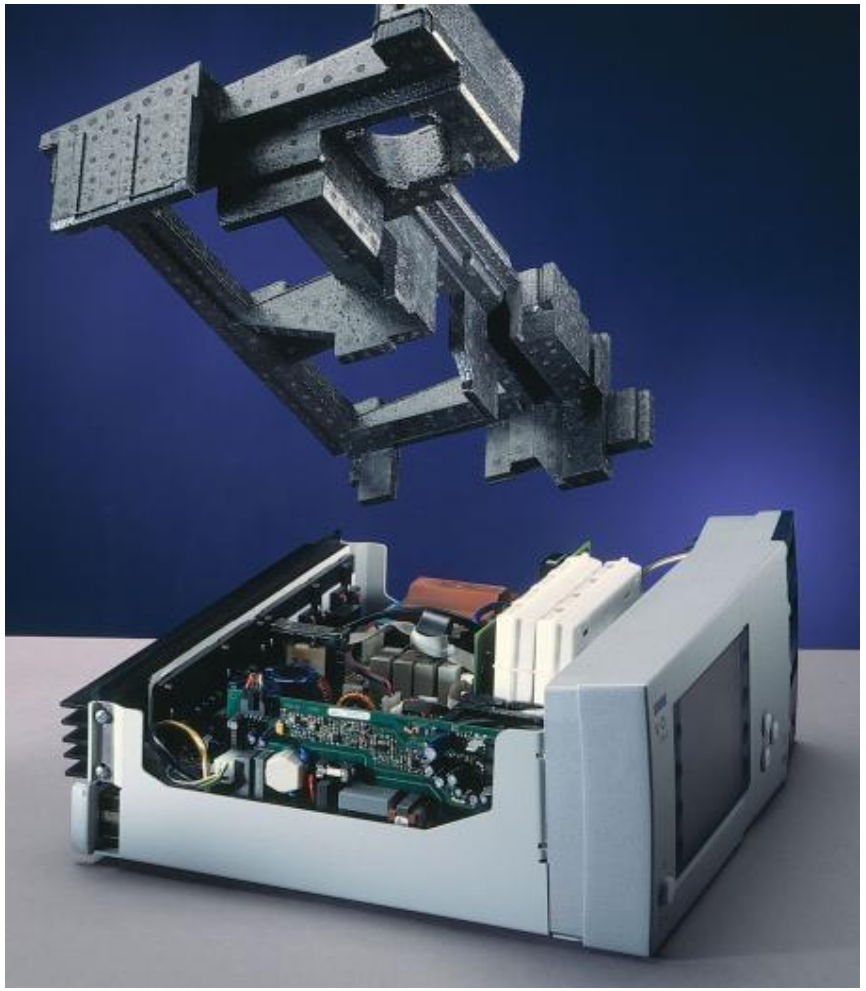
- Screws
- Brackets
- Wire tires
- Etc.

Source: resonetics.com

Electronic Assembly Packaging Concept EPAC

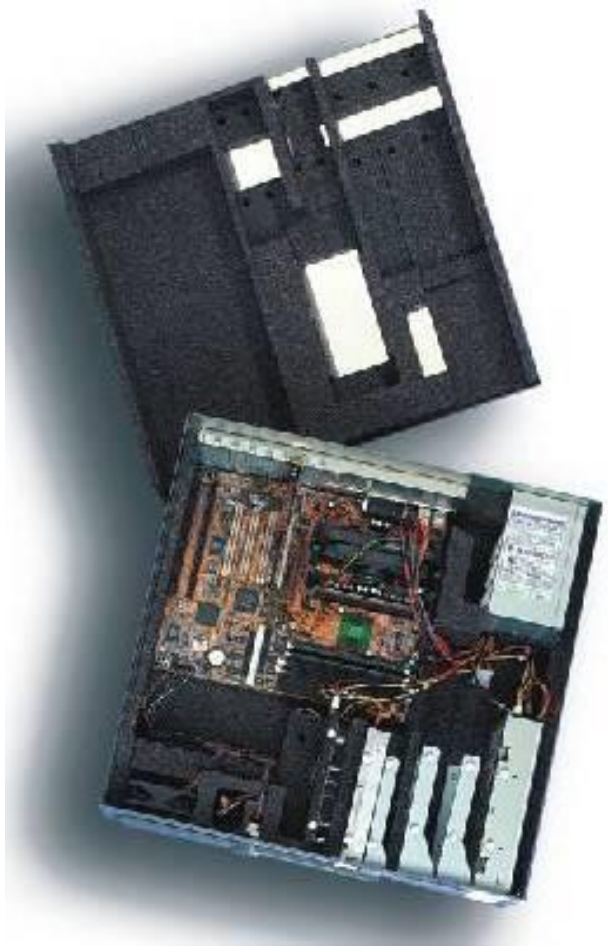
EPP As An Internal Structure

- EPP is used to replace a conventional “chassis” or internal construction of a product with a “sandwich” of custom molded EPP parts
- Pioneered & patented by Hewlett Packard engineers - in Germany in early 90’s
- Concept used in early mid 90’s in products such as:
  - Engineering Workstations
  - Peripheral Devices
  - Portable Defibulators
  - Analytical products



Electronic Assembly Packaging Concept EPAC

Results from HP workstation

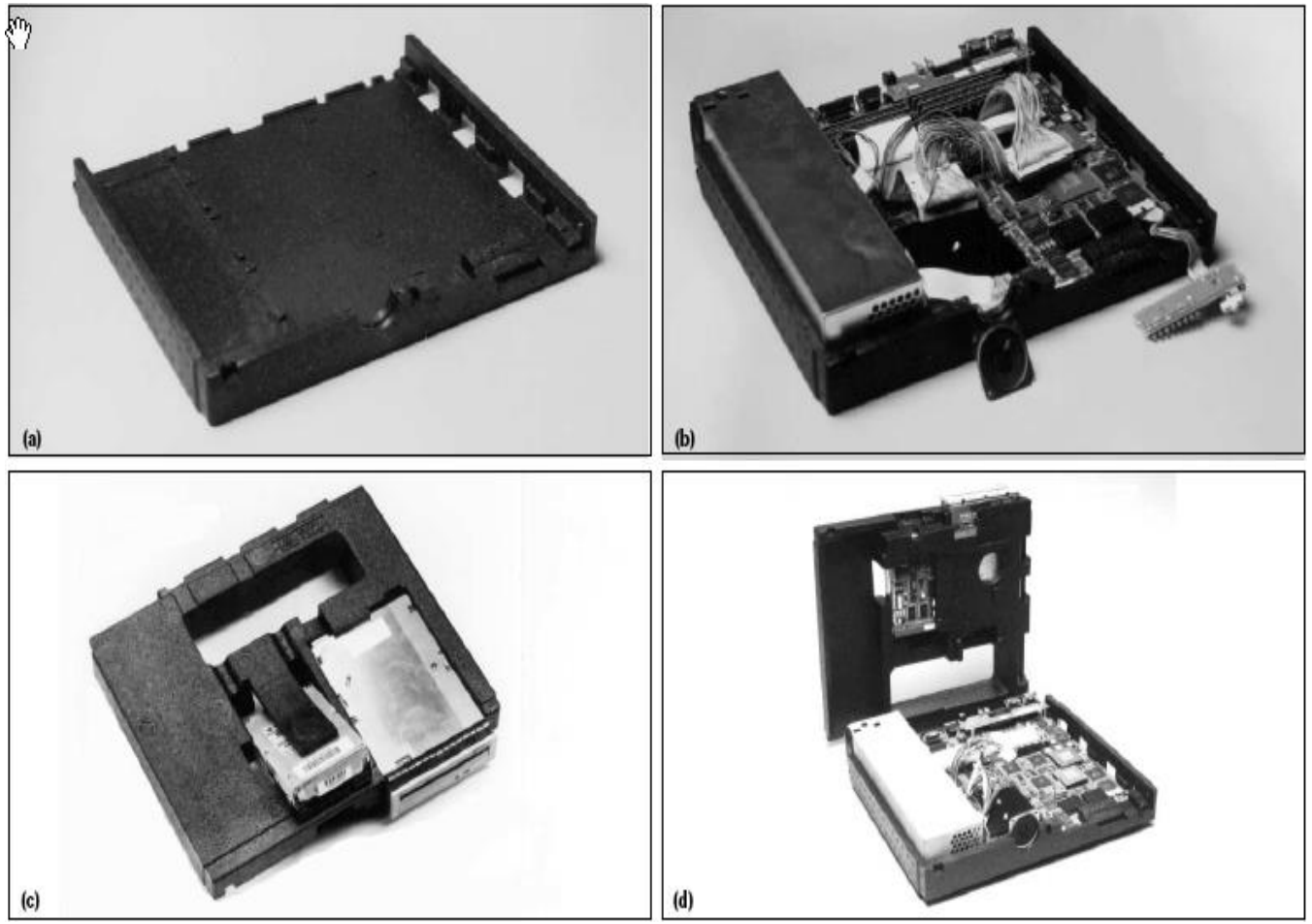


Benefits from Using EPAC

- 70% reduction in housing mech. parts
- 95% reduction in screw joints
- 50% reduction in assembly time
- 90% reduction in disassembly time
- 30% reduction in protective packaging
- 50% reduction in engineering time for mechanical development of housing
- 50% reduction in weight of plastic

Electronic Assembly Packaging Concept EPAC

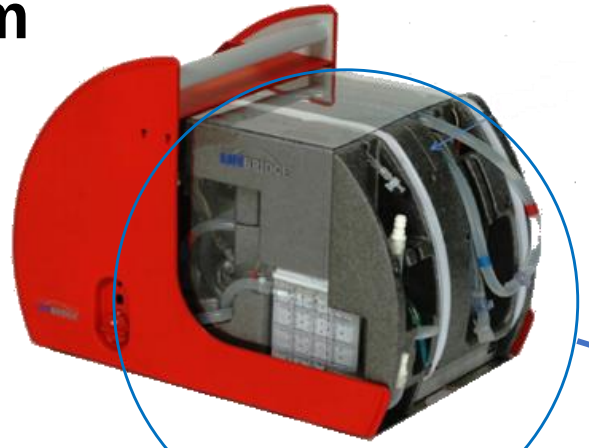
- Moreover, the E-PAC workstation included these additional benefits:
- Reduction in chassis parts
- One production step to produce molded parts
- Simple, fast, cost effective assembly
- Reduced product weight
- Good shock and vibration protection
- Cooling from air channels in the foam
- 100% recyclable material
- Reduced tolerance issues because of material flexibility

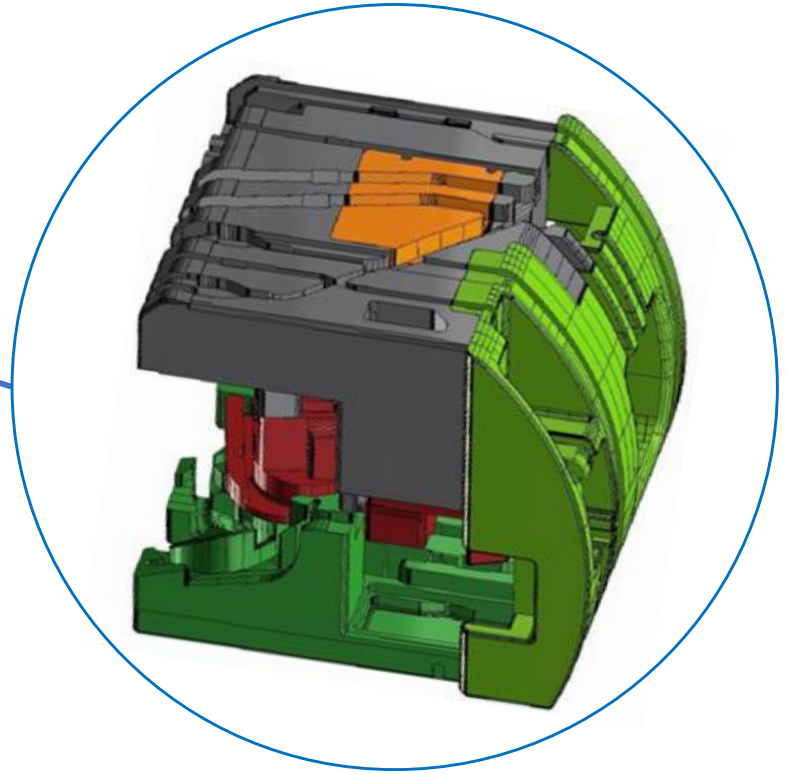


Advantages Using Molded Foam BDI conference June 6, 2012 R, Cole & D. Meeker

Electronic Assembly Packaging Concept EPAC

The Lifebridge® “Plug-and-Play” Extracorporeal Life Support System





- Significant weight reduction
- Form Fit - No fasteners
- Cables and tubes routed in the foam
- Recycling after use faster - no disassembly tools required

Advantages Using Molded Foam BDI conference June 6, 2012 R. Cole & D. Meeker

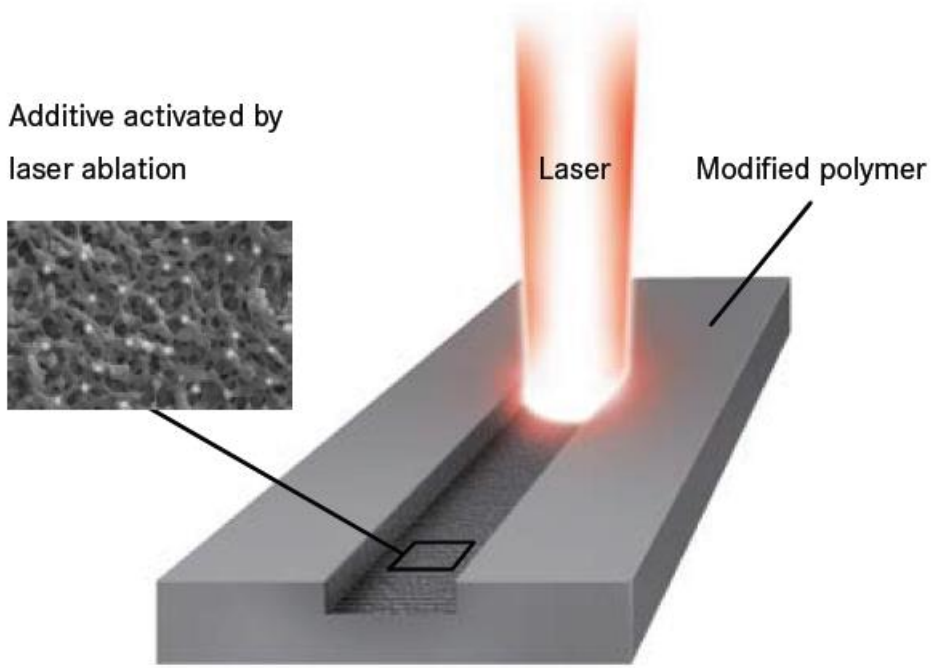
http://chronopause.com/chronopause.com/index.php/2011/02/25/the-lifebridge-b2t%C2%AE-%E2%80%9Cplug-and-play%E2%80%9D-extracorporeal-life-support-system/index.html

3D MID

- 3D Molded Interconnect Devices or 3D Mechatronic Integrated Devices (3D MID) are also known as Laser Direct Sintering (LDS), the manufacturing process used to expose the copper in the plastic.

A Better Product at a Lower Cost

Two-component injection molding and hot stamping are recognized methods in producing MIDs (molded interconnect devices). Both processes are bound to product-specific tools in integrating conductor structures to a component. Thus close-to-production prototyping is virtually impossible. The increasing miniaturization of circuits on MID components is leading to a clear rise in the set-up time and the costs. The LPKF LDS process prevents these problems and increases cost-effectiveness in prototyping and series production.



3D Molded Interconnect MID

3D-MID (LDS) Manufacturing Process

- Injection molding:

Injected molded parts with special LDS (Laser Direct Structuring) additive; molded part accuracy down to +/- 20 µm.

- Laser activation:

The line/space structure modulated by the laser beam;
laser spot minimum 80 µm with an accuracy of +/- 25 µm.

- Chemical plating:

Cu layer (8 +/- 3µm) on the modulated structure, **Ni** layer on top of the Cu layer (8 +/- 3 µm) and a flash **Au** layer
(0.1 +/- 0.05 µm) as a final layer; Line/space ratio down to 80/80 µm.

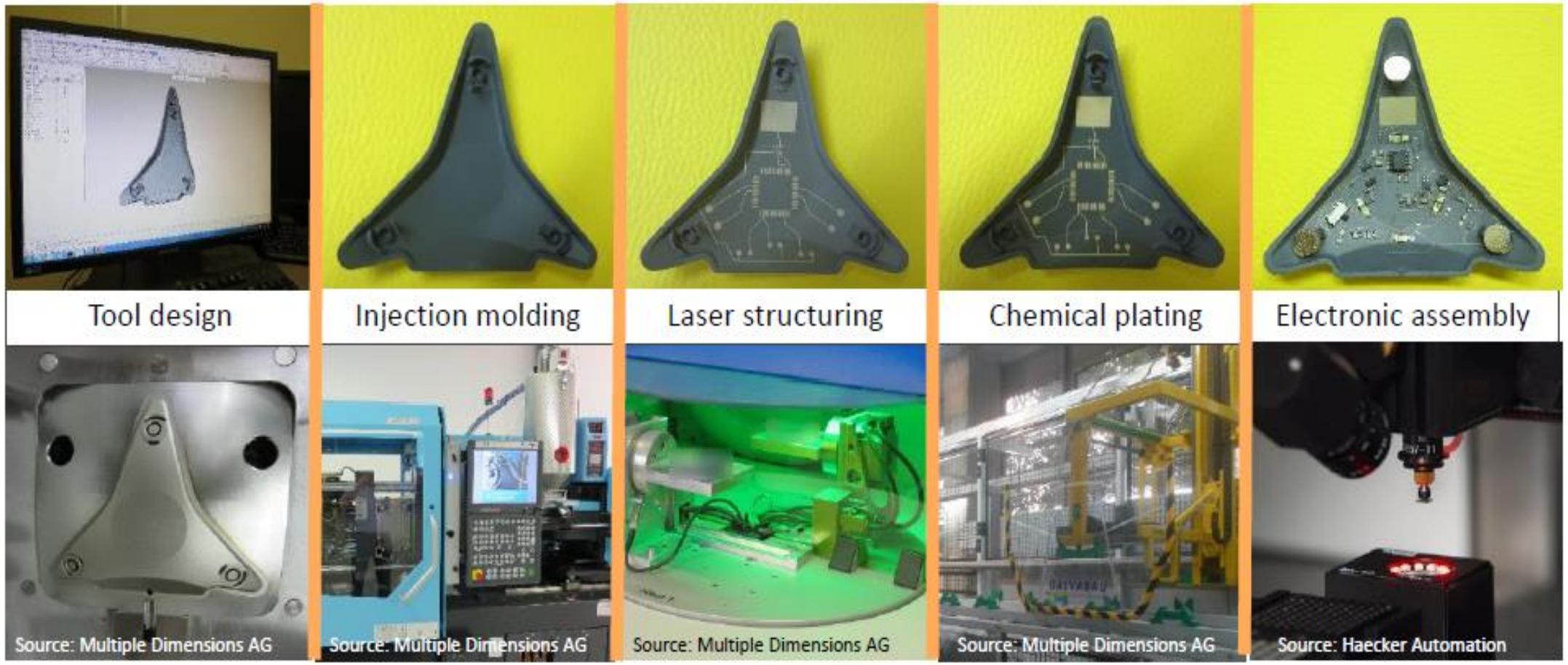
- Electronic assembly:

Assembly of electronic components by soldering, wire bonding, conductive gluing. Placement accuracy +/- 30 µm.

Source Multiple Dimensions Will Slate will.slade@multipledim.com

3D Molded Interconnect MID

From design to electronic assembly



Source Multiple Dimensions Will Slate will.slade@multipledim.com

3D Molded Interconnect MID

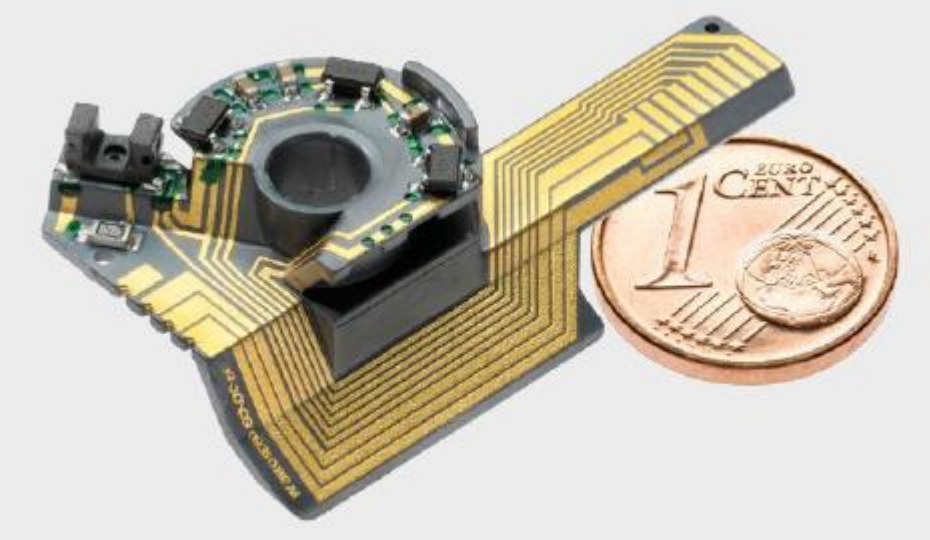
Applications:

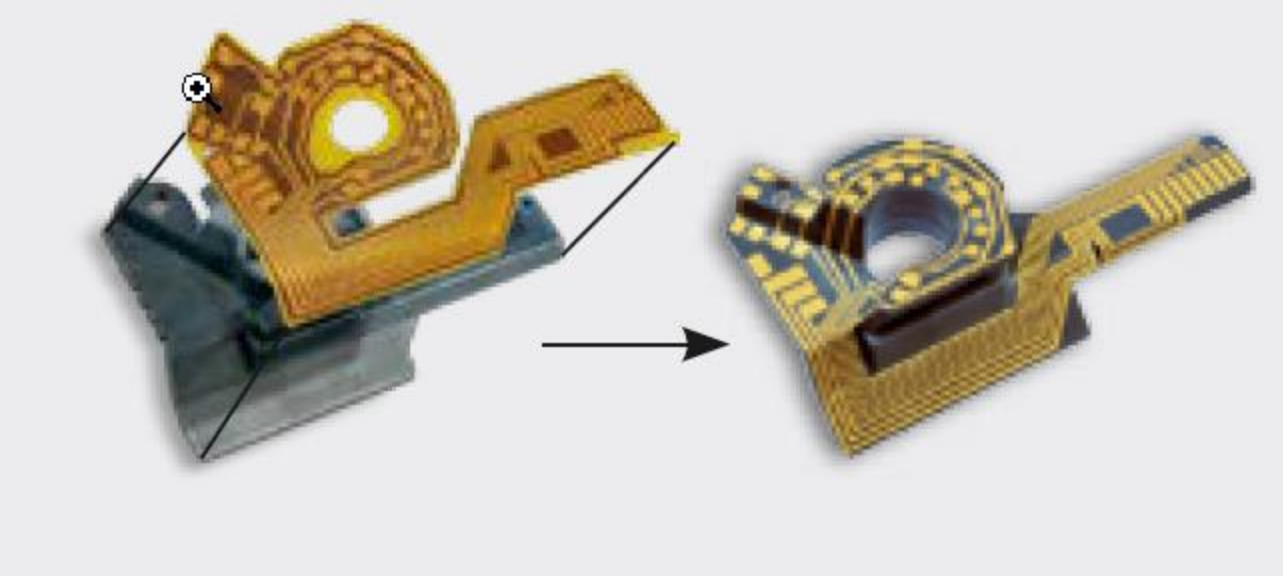
- Telecommunications
- Elimination of PBCs & Flex circuits
- Medical
- Automotive
- Security
- Connectors
- Packaging
- Military & Defense
- Measuring & Testing Equipment
- Antennas
- LEDs – Solar State Lighting, Camera, and Sensors

Figure 1: A molded interconnect device used in an automotive user interface

https://www.edn.com/design/pc-board/4427506/What-are-molded-interconnect-devices-

3D Molded Interconnect MID

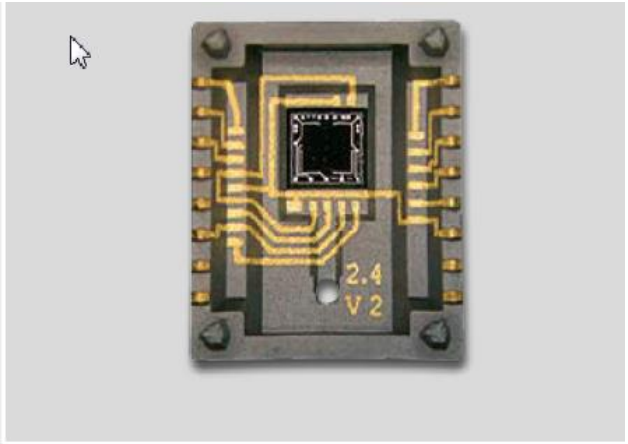




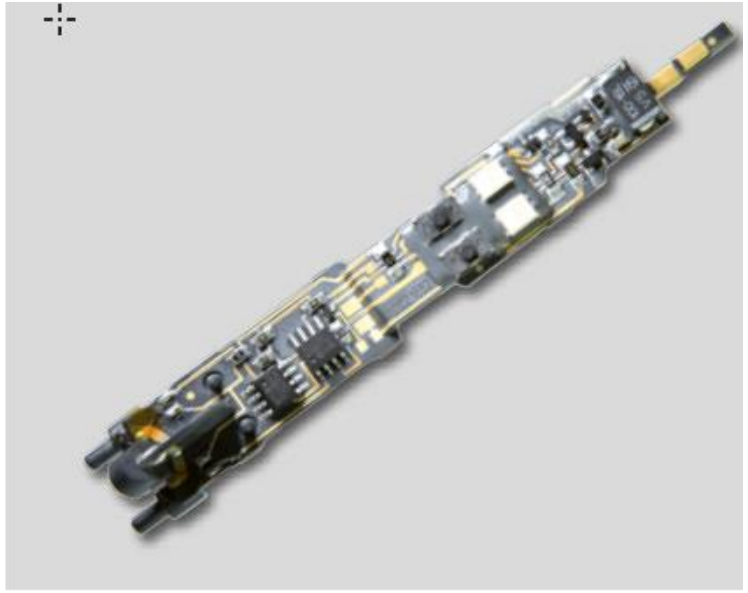
https://www.harting.com/DE/en-gb/markets/3d-mid-solutions-automobiles

3D Molded Interconnect MID

MID technology makes medical devices even more comfortable.
A classic LPKF LDS application: hearing aids that are light and compact
(Manufacturer: Siemens Audiologische Technik [Siemens Hearing Instruments])



Pressure sensor for industrial applications. The ASIC is integrated; mechanical connections are part of the enclosure (Manufacturer: Harting AG)



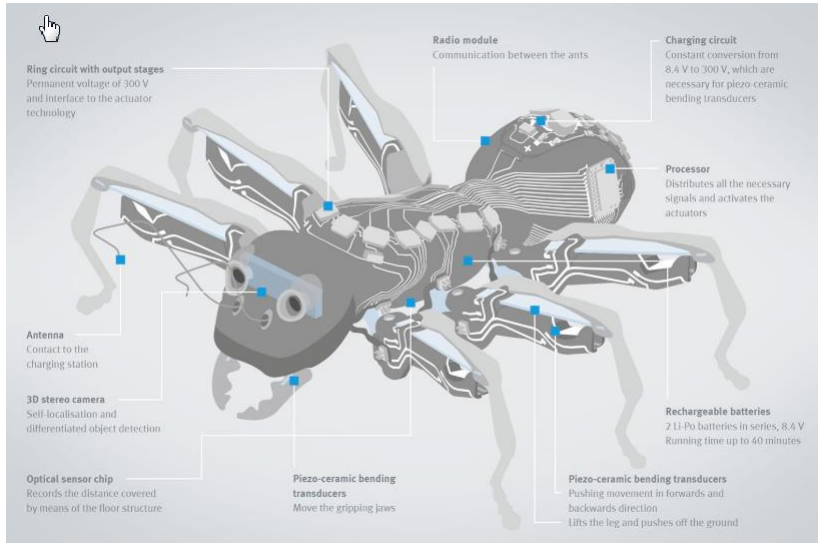
Dental hand piece (Manufacturer: KaVo Dental GmbH)

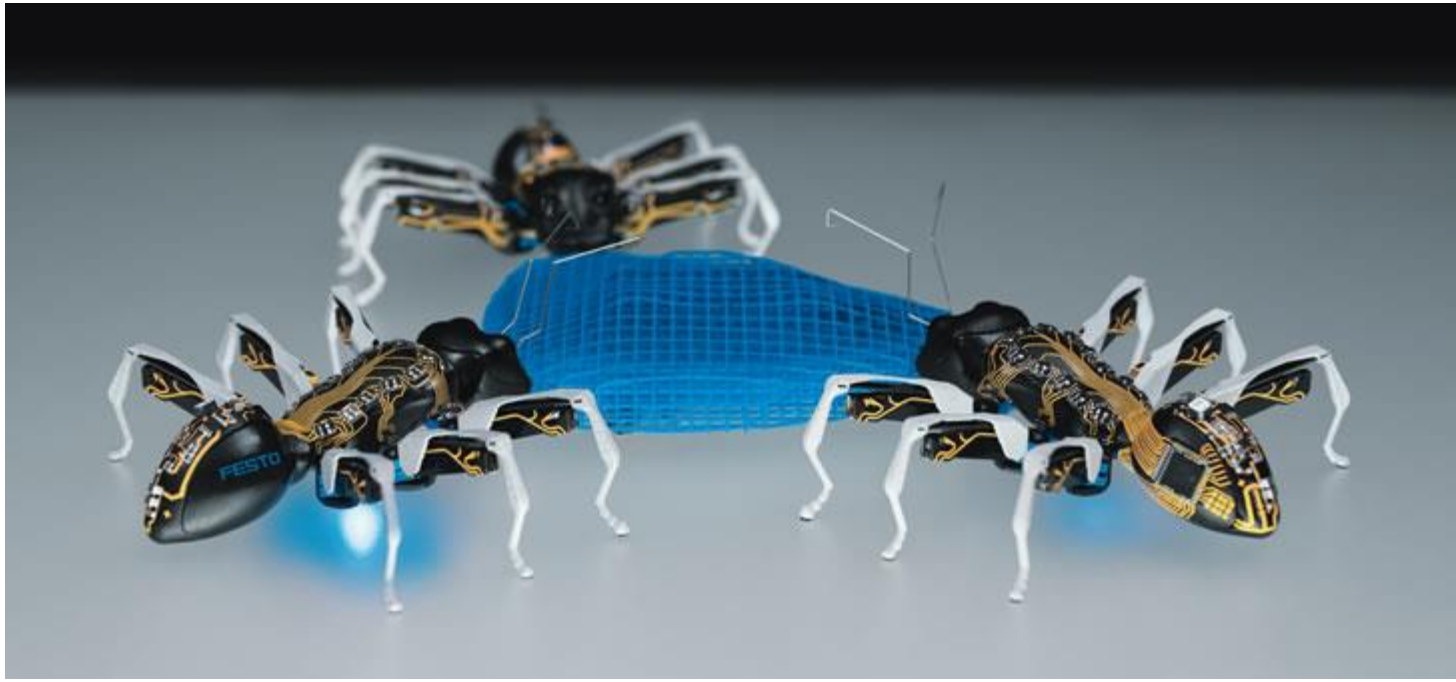
Steering wheel controls
(Manufacturer: TRW
Automotive for BMW)

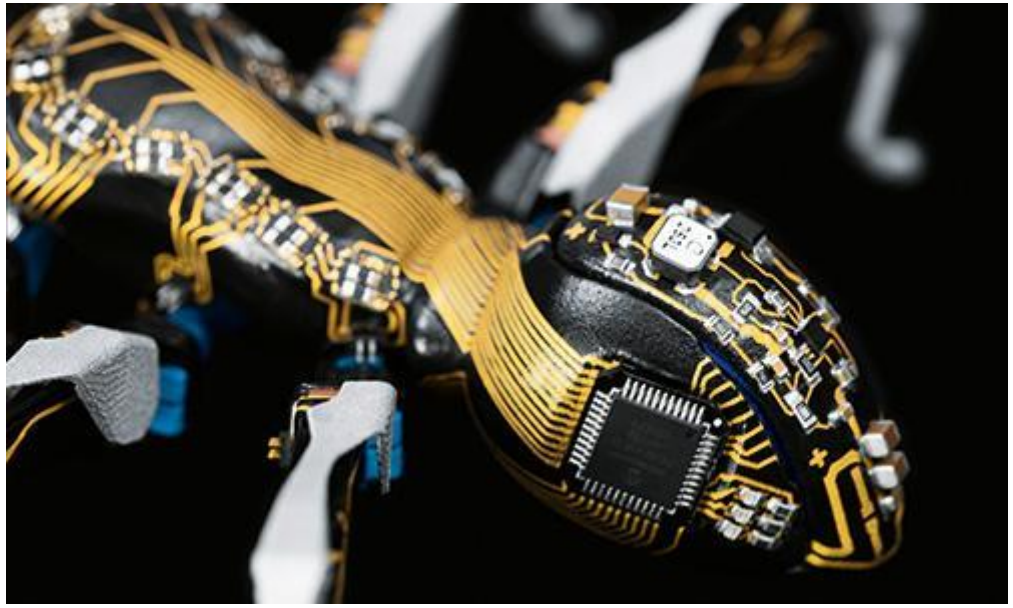
Cell Phone antenna's

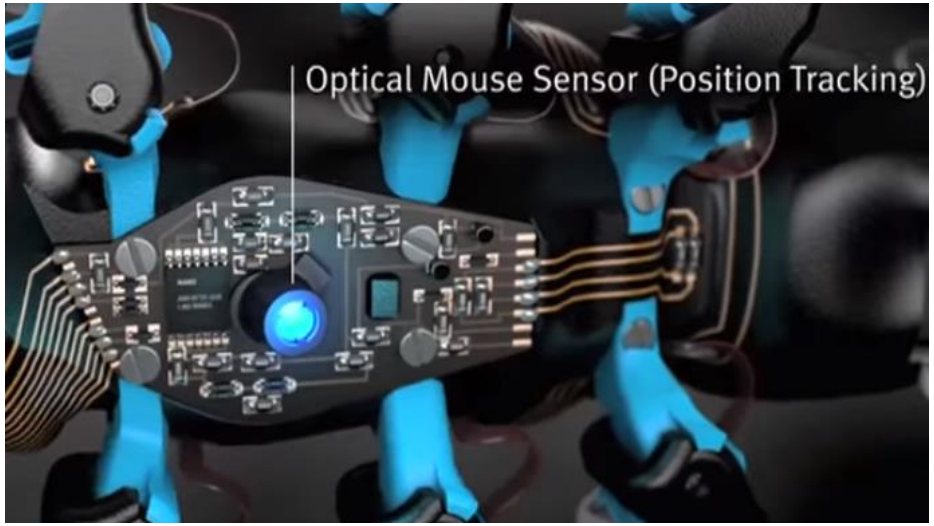
Three-Dimensional Circuits LPKF LDS: Laser Direct Structuring for 3D Molded Interconnect Devices- LPKF brochure

Festo ants









https://3dprint.com/54023/festo-3d-printed-bionicants/

3D Molded Interconnect MID

BENEFITS

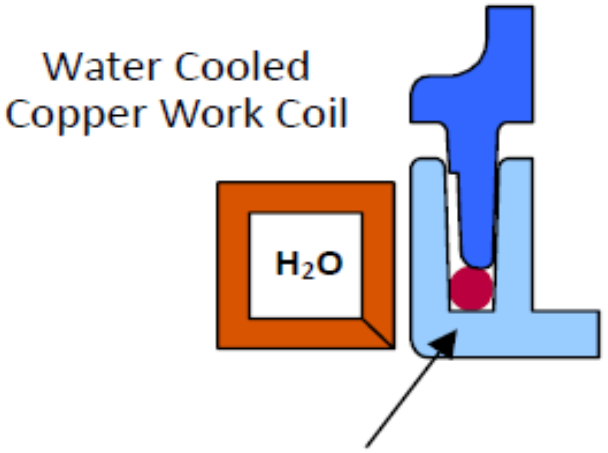
3D MID applications are only limited by your imagination. The final of combining electrical and mechanical functionality yields:

- Part count reduction through combined parts
- Miniaturization and reduced weight
- Function integration
- Assembly simplification
- Reliability
- Flexibility in being able to use 3 dimensions and mechanical properties of polymers

Electronic Magnetic Assembly Bonding EMABOND

Before Joining

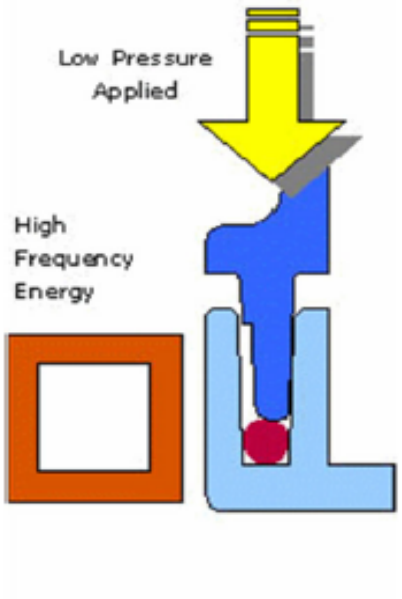
Emabond resin is deposited in the joint. The mating parts are brought together and placed within a fixture containing a work coil.



Emabond Resin is 100% Contained

During Joining

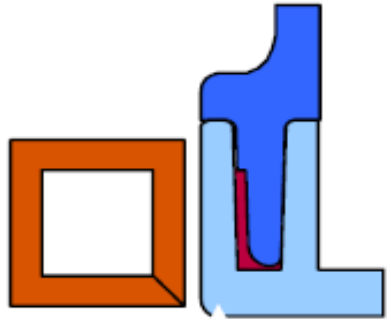
The activated coil heats the Emabond resin, causing the adjoining surfaces to melt.



Precise Heat Delivery from Power Source to Bond Line

After Joining

The Emabond resin has filled the gap. The process has fused the mating parts, resulting in polymer to polymer permanent bond.



Produces a Structural Joint Capable of High Shear Strength

The Process is Similar to Injection Molding the Joint!

Electronic Magnetic Assembly Bonding EMABOND

An EMABOND Electromagnetic Process can be used when:

- A hermetic seal is needed.
- Joining dissimilar materials.
- Joining highly filled materials.
- Currently using an adhesive to bond your parts together.
- A surface treatment prior to welding or bonding is required.
- Screwing parts together with gaskets is used.
- Welding or bonding multiple bond lines.
- Superior joint strength is required.
- Tool access side of part is a A-Surface.
- Experiencing high or costly joint failures.

Electronic Magnetic Assembly Bonding EMABOND

Consumer Electronics Sound Enclosure – Emabond

New Assembly Method - Emabond

Benefits > Savings

- ✓ Cycle time reduced from 11 min 45 sec to 40 seconds
- ✓ Eliminated WIP – test immediately
- ✓ Direct Material cost reduced by 74%
- ✓ Joint strength increased by 130%
- ✓ Floor space reduced from approx. 150 sq. ft. to 25 sq. ft.
- ✓ Operator reduction from 2 to 1

Economic Impact – Fast ROI

- ✓ Capital & Tooling $100,000
- ✓ ROI for above @ Volume = 2 months
- ✓ Significant Ongoing Savings

Material: PP – Cellulose filled to Glass filled PP

Joint: Flat to Flat with taper

Electronic Magnetic Assembly Bonding EMABOND

YETI LoadOut Bucket Anti-slip Ring

Benefits > Savings

- ✓ Eliminated costly adhesives
- ✓ Eliminated Surface Treatment
- ✓ Cycle time reduced
- ✓ Joint strength exceeds base material
- ✓ Floor space reduced nearly 400%
- ✓ Operator reduction from 3 to 1

Economic Impact – Fast ROI

- ✓ ROI @ Volume = < 12 months
- ✓ Significant Ongoing Savings YoY

Material: HDPE to Kraton TPE

Joint: Tongue to Groove

Electronic Magnetic Assembly Bonding EMABOND

Advantages of using EMABOND

- Eliminates costly Adhesives / Fasteners / O-Rings
- No need for surface treatment
- Part is done in seconds, no clamping fixtures or green strength time
- Less Work in Process
- Process allows for warped or mismatched parts
- Provides you the ability to Un-Weld assemblies to harvest components
- Less Scrap, no need to clean or de-flash parts after welding
- No Environmental issues
- Quick change tooling allows capital to be utilized across multiple applications

3D Printing

- In 1981, Hideo Kodama of Nagoya Municipal Industrial Research Institute published his account of a functional rapid-prototyping system using photopolymers.

- In 1984, Charles Hull made 3D-printing history by inventing stereolithography. It lets designers create 3D models using digital data that can then be used to create a tangible object. The key to stereolithography is a kind of acrylic-based material known as photopolymer

- By 1992, 3D Systems created the world's first stereolithographic apparatus (SLA) machine which made it possible to fabricate complex parts, layer by layer in a fraction of time that it previously had taken. That same year, startup DTM produced the world's first selective laser sintering (SLS) machine — which shoots a laser at a powder instead of a liquid.

3D Printing Reusable tooling

2020 JT Profighter – Cost Analysis

3D Printed Top Fingers

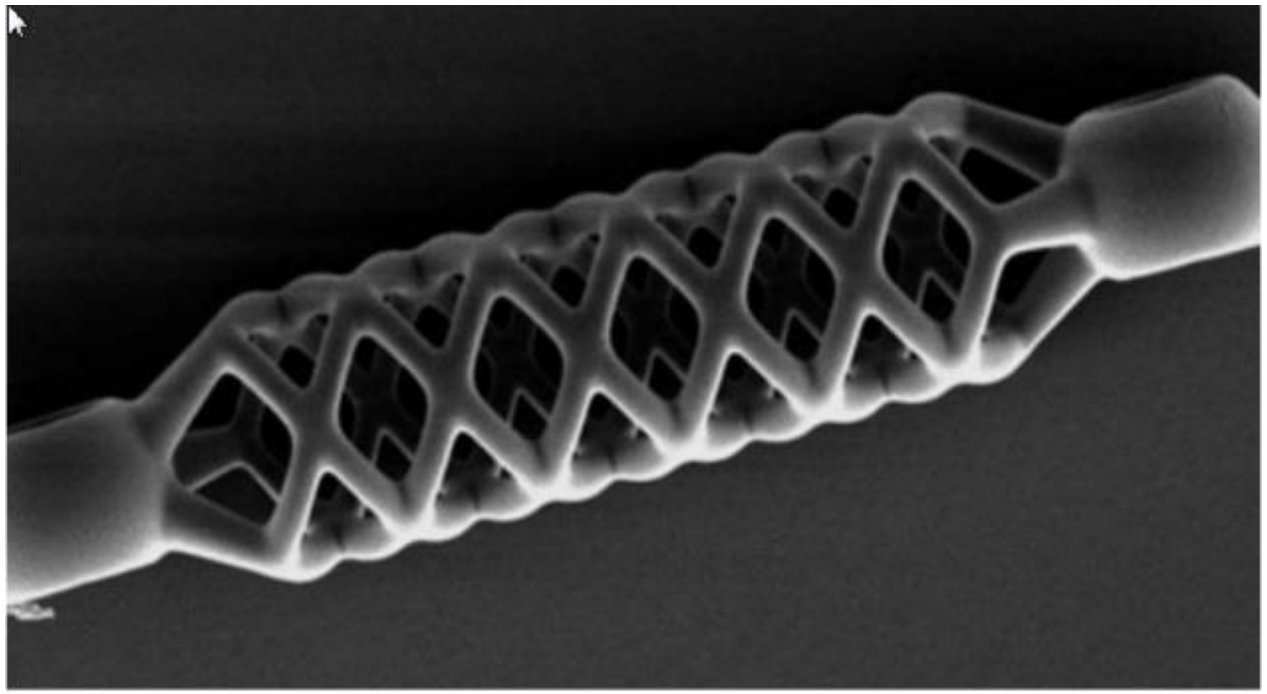
- $16,640
- 3D print finger and TPU tip
- $128 per assembled finger
  - 130 fingers required on initial order

Injection Molded Fingers

- $21,345
- Two new injection molds
  - $9,750 / each
  - Requires Capital approval
- Stand alone finger cost
  - $6.50 / each
  - 130 fingers required on initial order
- Two setup charges
  - $500 / each

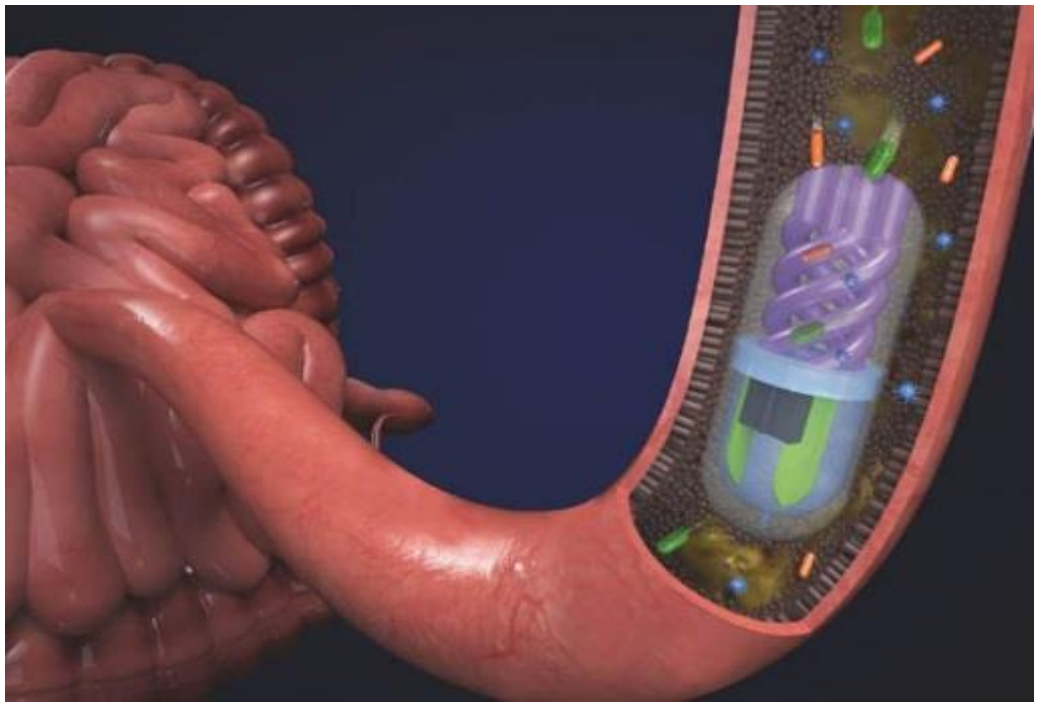
creativetechniques

3D Printing Medical



This microstent is just 50 micrometers (0.05 mm) wide and half a millimeter long. (Picture: Carmela de Marco / ETH Zurich)

This microstent is just 50 micrometers (0.05 mm) wide and half a millimeter long.



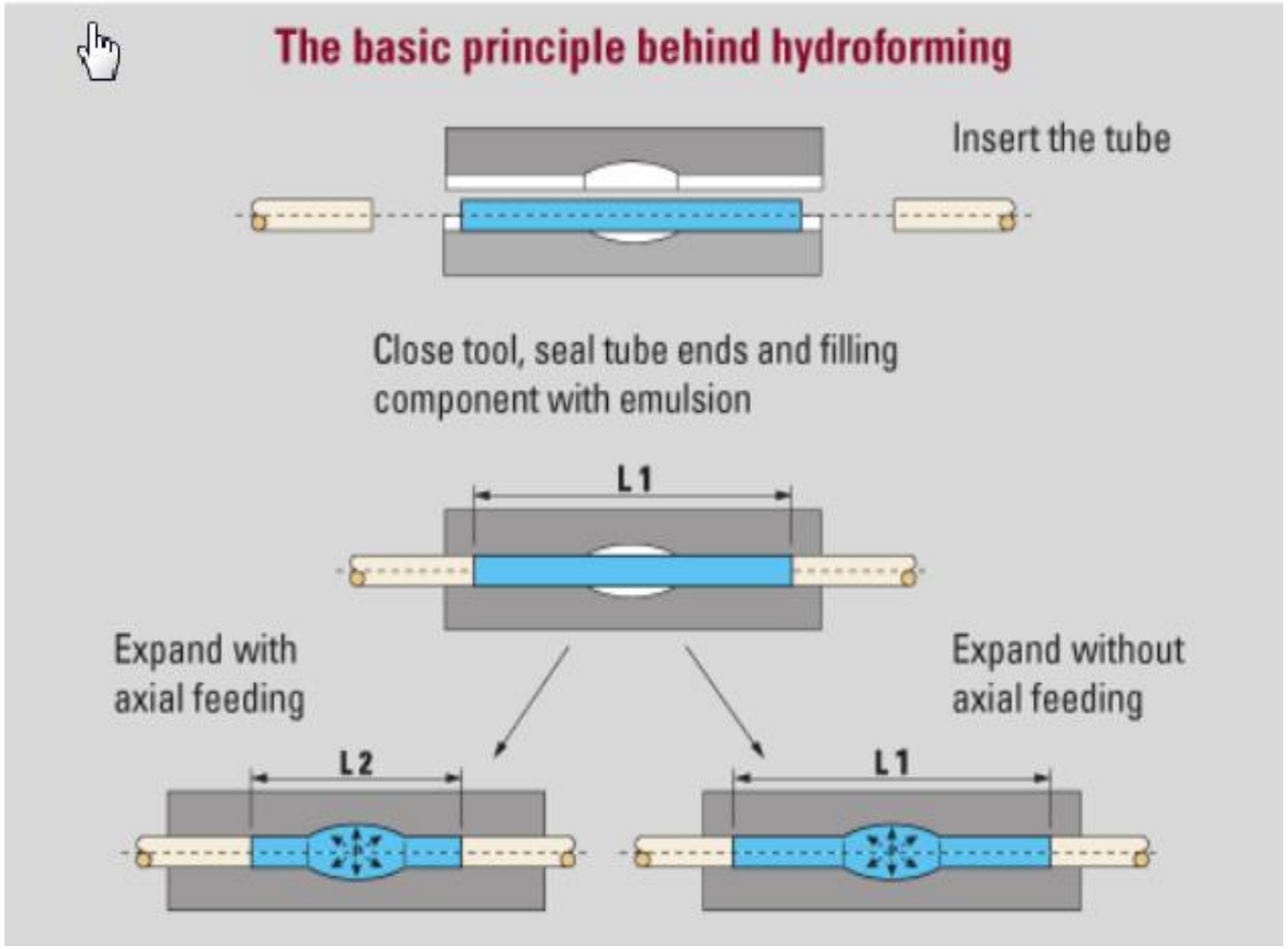
Tufts university on a 3D printed pill that samples gut microbiome

Hydroforming

- The process of hydroforming is based on a 1950’s patent for hydramolding by Fred Leuthesser, Jr. and John Fox of the Schaible Company, Cincinnati, OH.[2] It was originally used in producing kitchen spouts because it not only strengthened the metal, it also produced less "grainy" parts allowing for easier metal finishing.

- Hydroforming is a metal fabricating and forming process that shapes metals such as steel, stainless steel, copper, aluminum, and brass. This process is cost-effective. It requires a special type of die molding that utilizes highly pressurized fluid to form the metal.

Hydroforming Process Tubes



https://www.fischer-group.com/en/fischer_companies/fischer_hydroforming/methods_and_development.php?navanchor=2110101

Hydroforming Benefits

- Creation of complex, 3-dimensional geometries and cross-sectional and perimeter enhancement in a few process steps.
- Costs reduced through material reduction due to thin-walled tubes (wall thickness, weight and installation space compared to cast or bent parts with the same or higher static strength)
- The ability to replace several work steps (joining, soldering, welding, milling) with only one hydroforming component.
- A high degree of measurement and form precision.
- Extensive repeat accuracy of geometries.
- Requires only one hydroforming tool to create complex parts.
- Elimination of subsequent operations due to geometry advantages.
- Allows material diversity: aluminum, stainless, brass, copper, nickel-based alloys.
- Standardization of components across entire product range.

Hydroforming

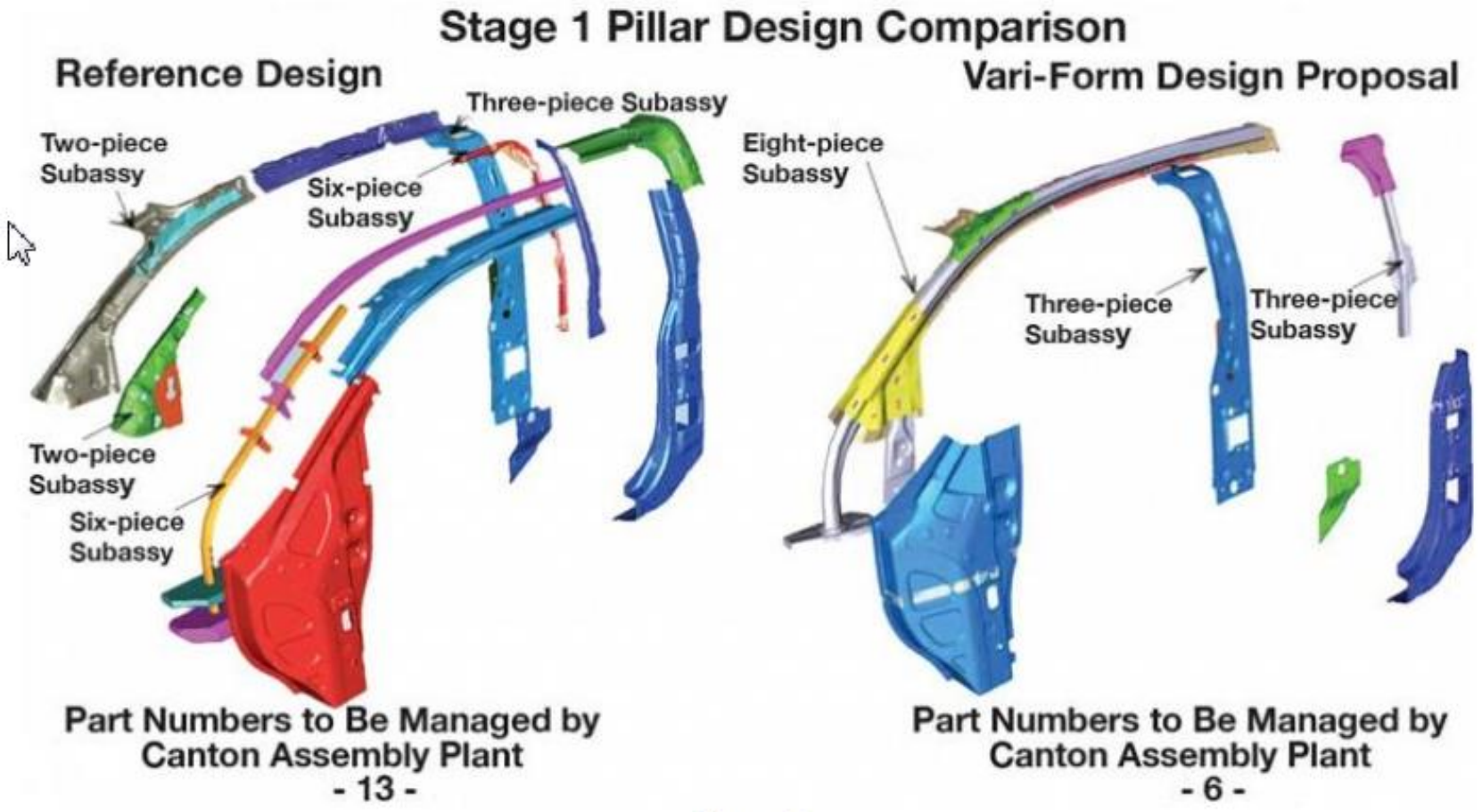


Figure 1
The reference design for the 2016 Nissan Titan was intended for an update to the truck's design, which led to a redesign of the jamb, A-pillar, and roof rail (left). The engineering staff at Vari-Form worked with Nissan engineers to develop a lighter-weight assembly that reduced the part count.

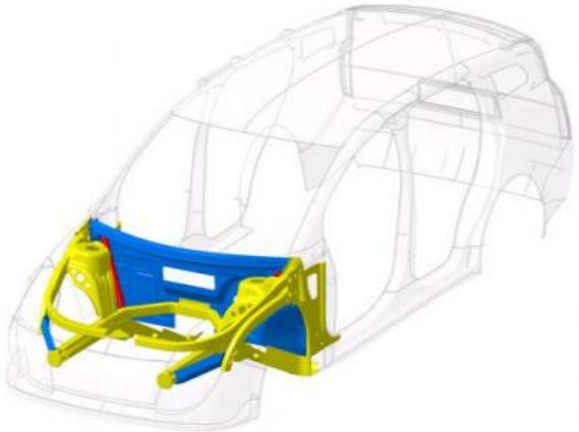
https://www.thefabricator.com/article/hydroforming/hydroforming-continues-to-pick-up-market-share-enhance-vehicle-safety

Hydroforming

VARI-FORM
THE LEADER IN HYDROFORMING TECHNOLOGIES

Front End Cost Comparison

EDAG Cost Model Used



Cost

Piece Cost*	12% savings over stamped
Tooling*	31% savings over stamped

*(includes component, sub-assy, and body shop assy. costs)

https://www.autosteel.org/-/media/files/autosteel/great-designs-in-steel/gdis-2013/hydroform-intensive-body-structure-with-advanced-and-ultra-highstrength-steels--phases-i--ii.ashx

Hydroforming

The Facts Behind Metal Spinning and Hydroforming Kagan Pittman posted on March 31, 2016

https://www.helandermetal.com/hydroforming-services

Friction Stir Welding

- Friction stir welding (FSW) was invented by Wayne Thomas and Colleagues at TWI in 1991.

- **The Welding Institute** or **TWI** is a research and technology organization, with a specialty in welding. With headquarters six miles south of Cambridge, Cambridgeshire, England, since 1946, and with facilities across the UK and around the world. TWI works across all industry sectors and in all aspects of manufacturing, fabrication and whole-life integrity management technologies.

- TWI services include consultancy, technical advice, research and investigation for industrial member companies and public funding bodies. It also offers training and examination services in NDT, welding and inspection across the globe.

Friction Stir Welding

TWI Ltd (The Welding Institute) is one of the world's leading R&D institutes for welding and joining technology. It is based on Granta Park near Cambridge (UK).

Employing over 800 staff, TWI serves 700 Industrial Member companies across 4500 sites in 80 countries. The formation in 1922 of its professional institution, The Welding Institute, and the later establishment of the British Welding Research Association (BWRA) in 1946 provided the basis of the company group as it is today. The Welding Institute currently has a separate membership of over 6000 individuals.

Friction Stir Welding

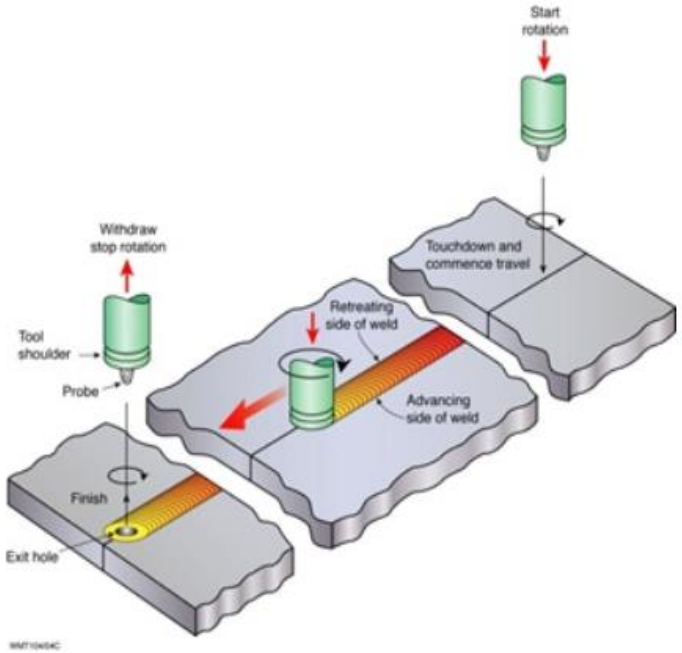
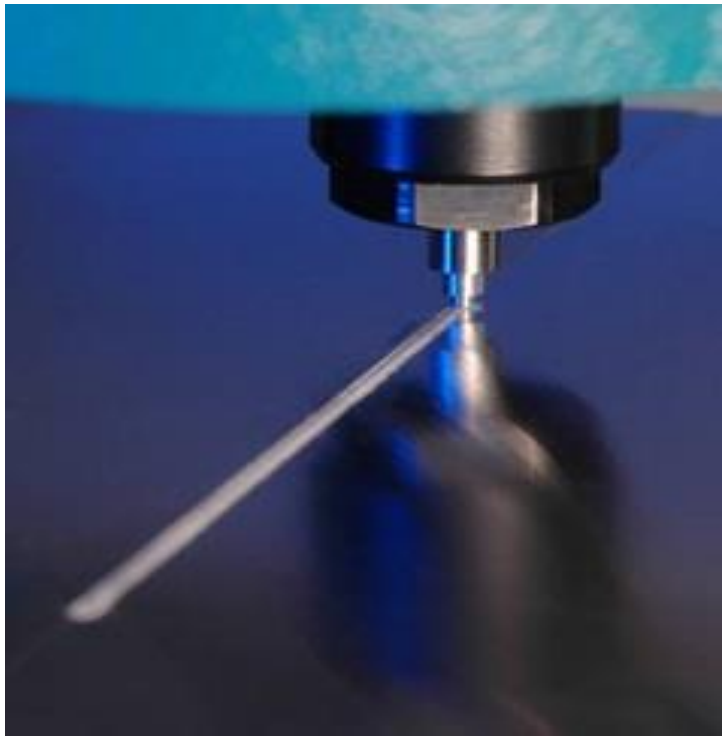


Figure 1: Schematic of the friction stir welding process



The process of friction stir welding spins a head slowly through a material melting it as it spins while moving forward, leaving behind a completely welded area.

https://www.twi-global.com/technical-knowledge/faqs/faq-what-is-friction-stir-welding

Friction Stir Welding

The centre tunnel of the Ford GT is made from two aluminium extrusions friction stir welded to a bent aluminium sheet and houses the fuel tank

The bulkhead and nosecone of the Orion spacecraft are joined using friction stir welding.

The high-strength low-distortion body of Hitachi's A-train *British Rail Class 395* is friction stir welded from longitudinal aluminium extrusions

Longitudinal and circumferential friction stir welds are used for the Falcon 9 rocket booster tank at the SpaceX factory

Thomas, WM; Nicholas, ED; Needham, JC; Murch, MG;Temple-Smith, P;Dawes, CJ.*Friction-stir butt welding*, GB Patent No. 9125978.8, International patent application No. PCT/GB92/02203, (1991)

Friction Stir Welding

Benefits of the Process:

- Low distortion and shrinkage, even in long welds.
- Excellent mechanical properties in fatigue, tensile and bend tests; in many case improved micro structure and increased strength.
- No arc or fumes.
- No porosity in weld zone.
- No splatter during welding.
- Welds 3-dimensionally.
- Energy efficient.
- One tool can typically be used for up to 1000m of weld length in 6XXX series aluminum alloys.
- No filler wire required.
- No gas shielding for welding aluminum.
- Tolerance to imperfect weld preparations and joint match up - thin oxide layers can be accepted.
- No grinding, brushing or pickling required in mass production.
- Can weld aluminum larger than 75mm in one pass.

I KEEP six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who *

Questions

* Six Honest Serving Men Rudyard Kipling 1902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