



600 Cannonball Lane  
O'Fallon, MO 63366

# The Design Engineer's Role in the Casting Supply Chain



Bruce Willson

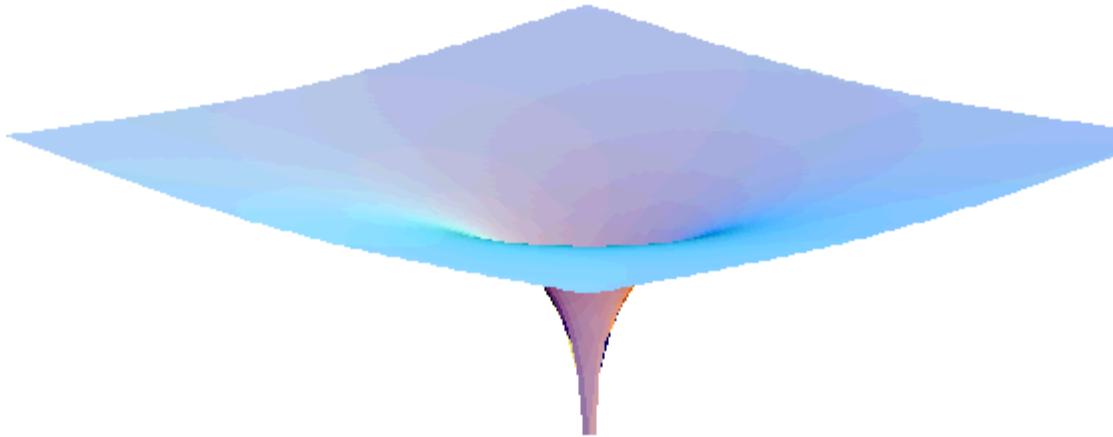


<http://www.ofalloncasting.com/>



# The Design Engineer's Role

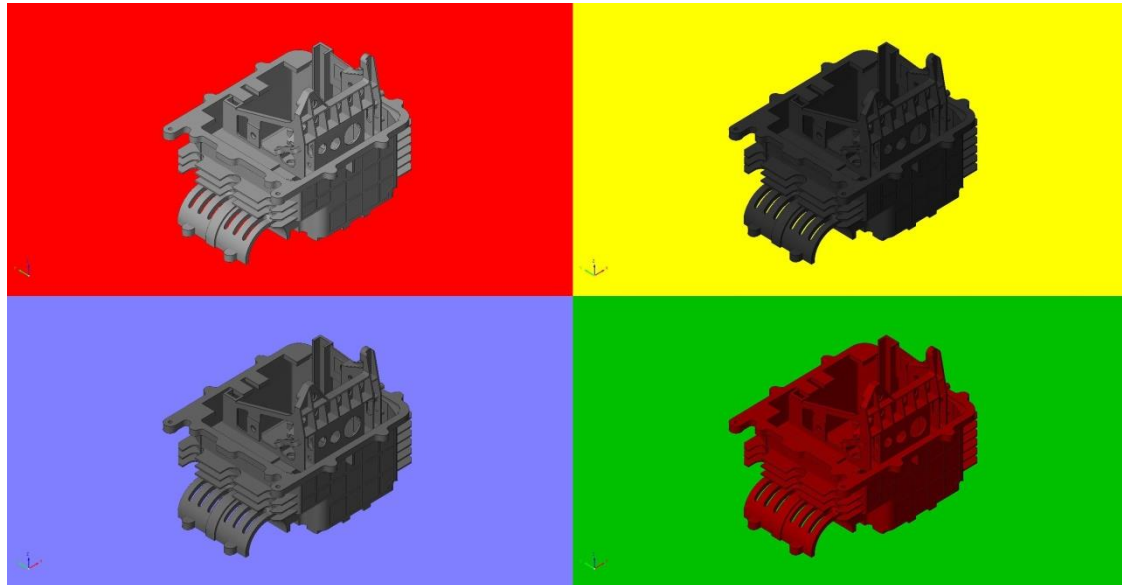
- ∞ Definition of an Engineer
  - Someone who knows almost everything
  - About almost nothing



# The Design Engineer's Role

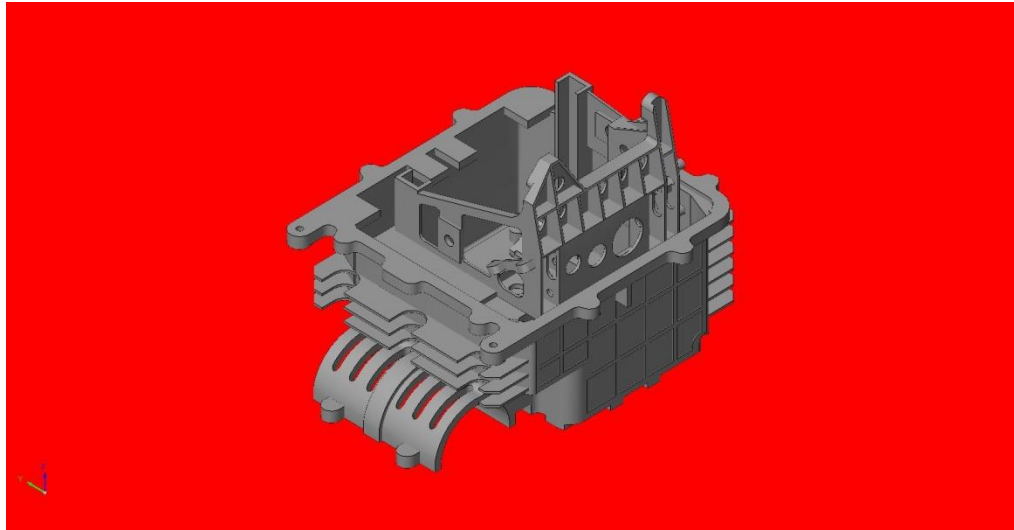
70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability
- Reliability
- Inventory
- Administrative costs
- **Affordability**



# The Design Engineer's Role

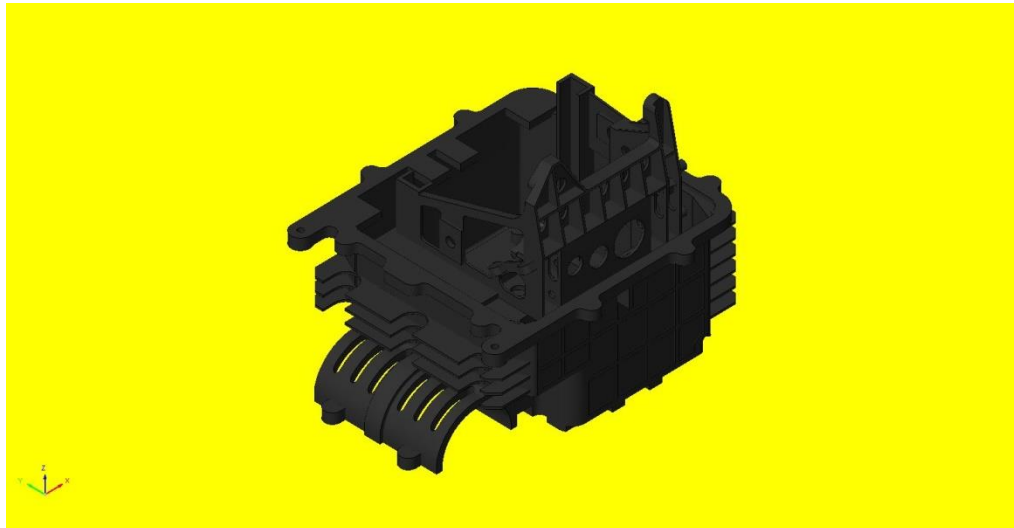
Premise: Castings present a cost effective solution for the manufacture of complex Near Net shapes that reduce Part Count and improve the affordability, manufacturability and reliability of the end product



Successful casting design requires some specialized expertise and an appreciation for the strengths and weaknesses of the foundry process.

# The Design Engineer's Role

- ∞ Provide an Overview of the Investment Casting Process
- ∞ Explore Investment Casting Strengths & Weaknesses
- ∞ Develop an Understanding of The Design Engineer's Role



# Casting Processes — American Foundry Society

## ∞ Sand Casting Processes

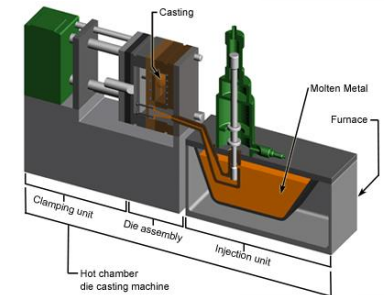
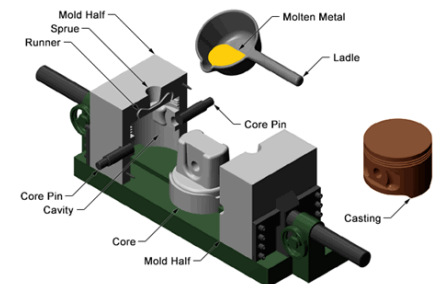
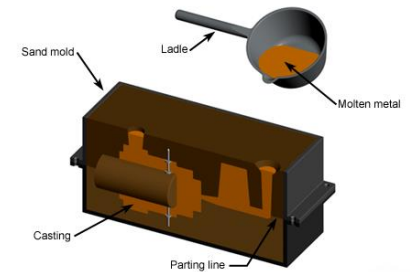
- Green Sand
- Chemically Bonded Sand
  - Gas Catalyzed / Coldbox Systems
  - Shell Process
  - Nobake / Airset Systems
- Unbonded Sand
  - Lost Foam
  - V-Process

## ∞ Permanent Mold Processes

- Die Casting
- Permanent Mold Casting (Gravity Diecasting)
- Low-Pressure / Vacuum Permanent Mold Casting

## ∞ Ceramic & Plaster Processes

- Investment Casting
- Ceramic Molding
- Plaster Molding



# The Design Engineer's Role

- ☞ **The Investment Casting Process is divided into two main branches which differ by their ceramic molding method.**

**Solid Mold Process** - Wax Pattern Assemblies are suspended within a “casing” which is filled with a ceramic “investment”. Once the investment is dry the Solid Mold may be fired and cast.

The Solid Mold process was the prevalent Investment Casting method prior to the advent of the Shell Process in the 1970's and remains in use today to manufacture castings of intricate detail



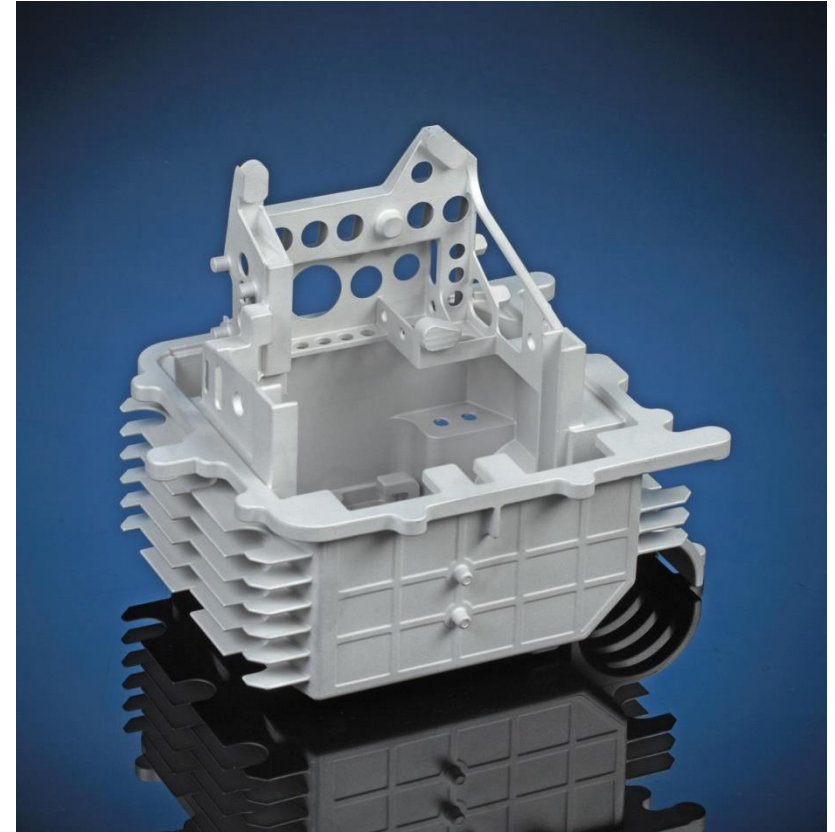
**Shell Process** - Wax Pattern Assemblies are repeatedly dipped into vats of ceramic slurry and sand to form a shell. The shell is then dried, fired & cast.

The Shell Process provides economies in material usage and eliminates the need for a casing.



# The Design Engineer's Role

- ∞ **Definition:** Investment Casting is a foundry process by which a cast metal part is produced from a ceramic (investment) mold that has been formed by a disposable (wax or plastic) pattern.
- ∞ Investment Casting is sometimes also known as *Lost Wax Casting* or as *Precision Casting*.
- ∞ The American Foundry Society has identified 255 U.S. Investment Casting foundries.\*

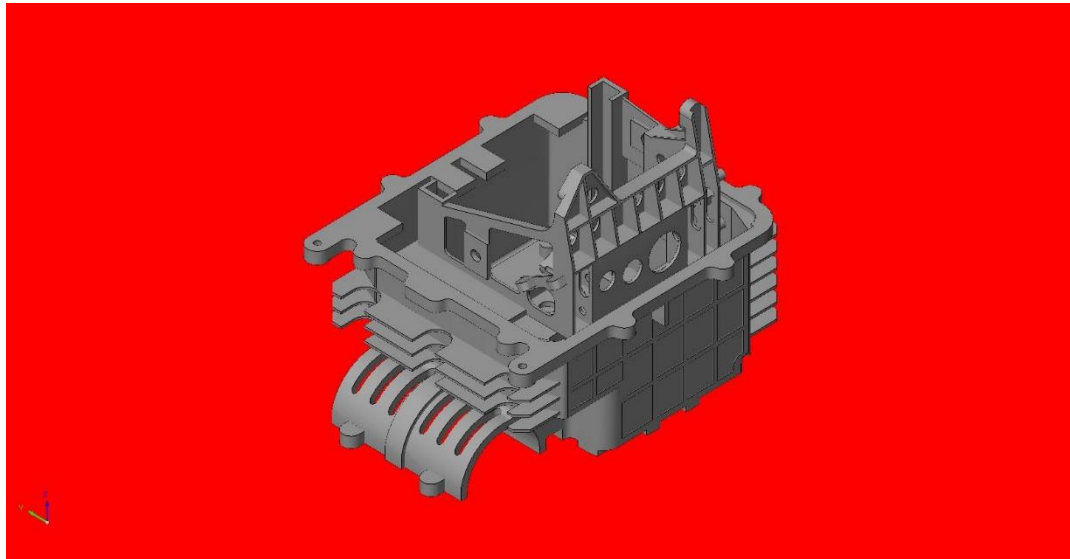


AFS/MCDP -2013 Casting of the Year



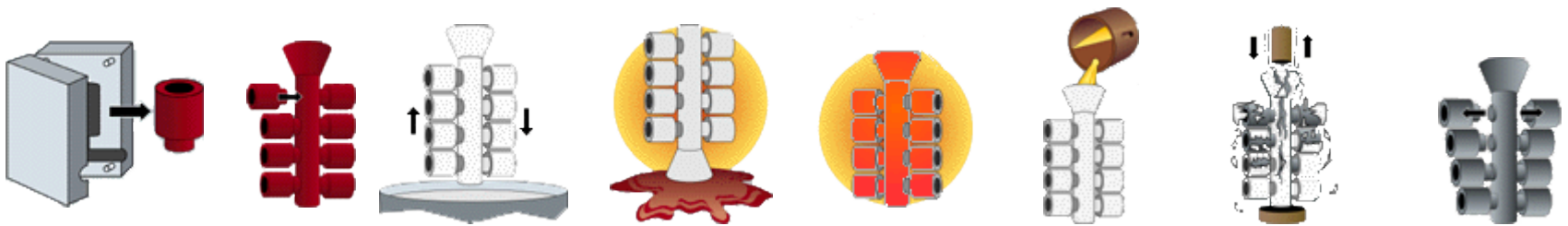
# The Design Engineer's Role

## The Investment Casting Process



# Investment Casting Process

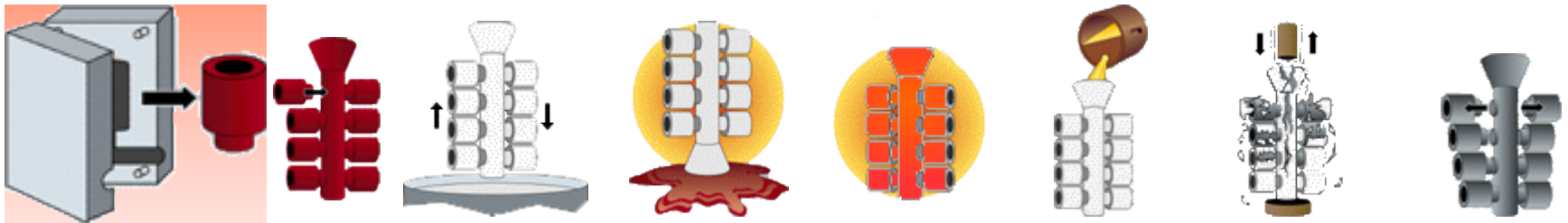
∞ Eight basic steps to Manufacture an Investment Casting



<http://www.investmentcasting.org/video.asp>

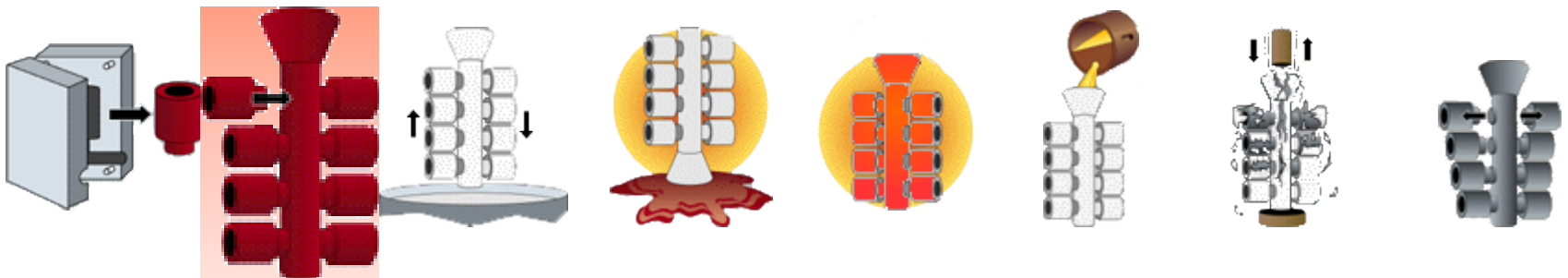
# Investment Casting Process

Step 1: Produce a disposable (wax) pattern from mold



# Investment Casting Process

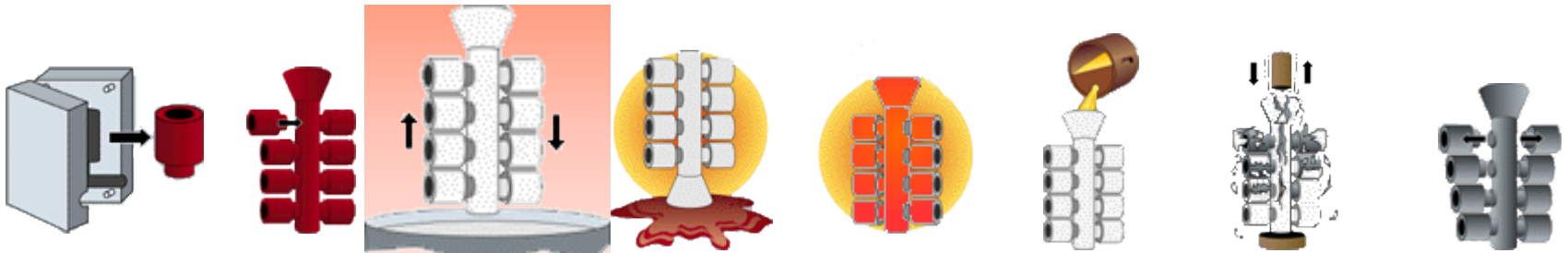
Step 2: Assemble multiple patterns to gating system



Wax Pattern Assembly

# Investment Casting Process

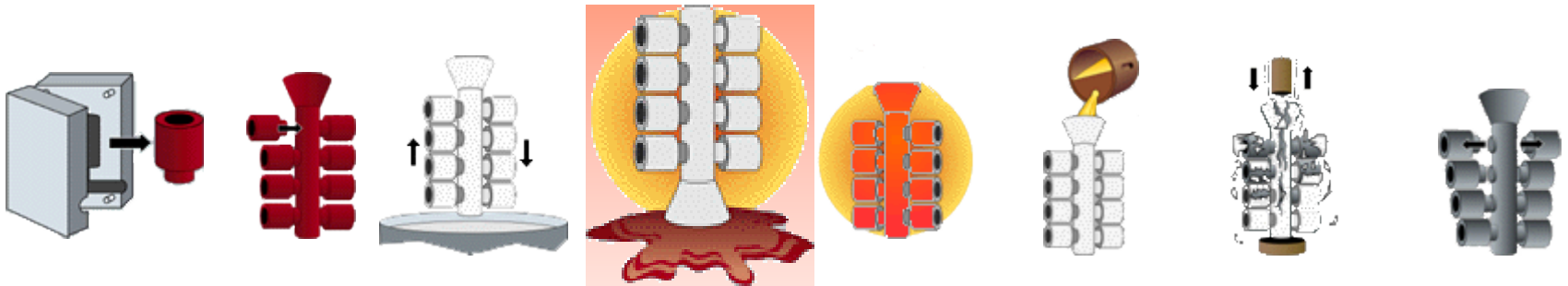
## Step 3: Form Ceramic Shell around Wax Assembly



Layer of Ceramic Shell being applied by robot

# Investment Casting Process

## Step 4: De-Wax Ceramic Shell



Steam Boilerclave to de-wax shell

# Investment Casting Process

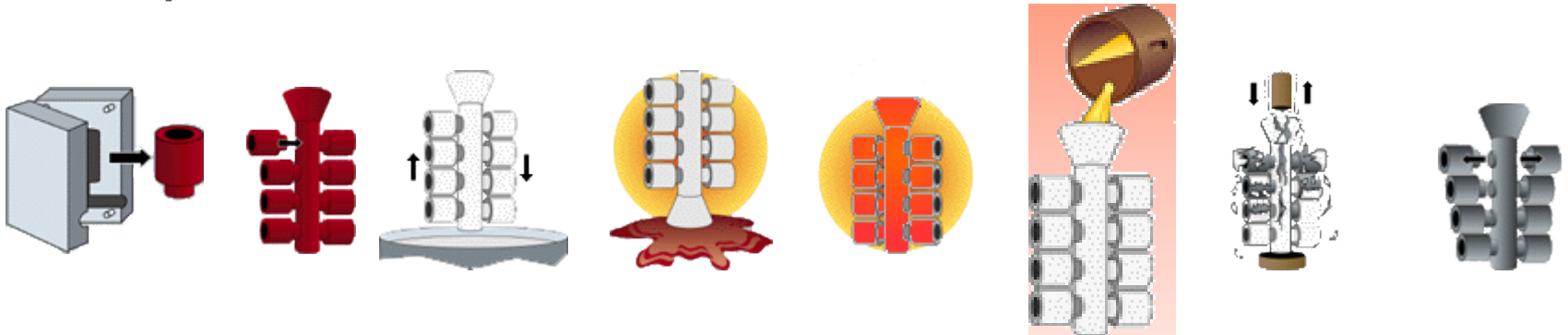
## Step 5: Fire the Ceramic Shell



Ceramic Shells being Fired

# Investment Casting Process

## Step 6: Cast metal into fired Ceramic Shell

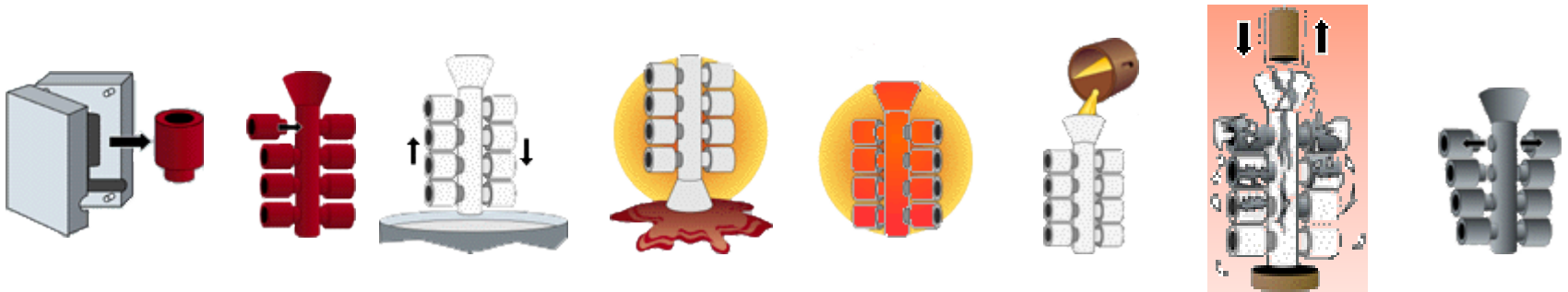


Casting Ceramic Shell from Ladle



# Investment Casting Process

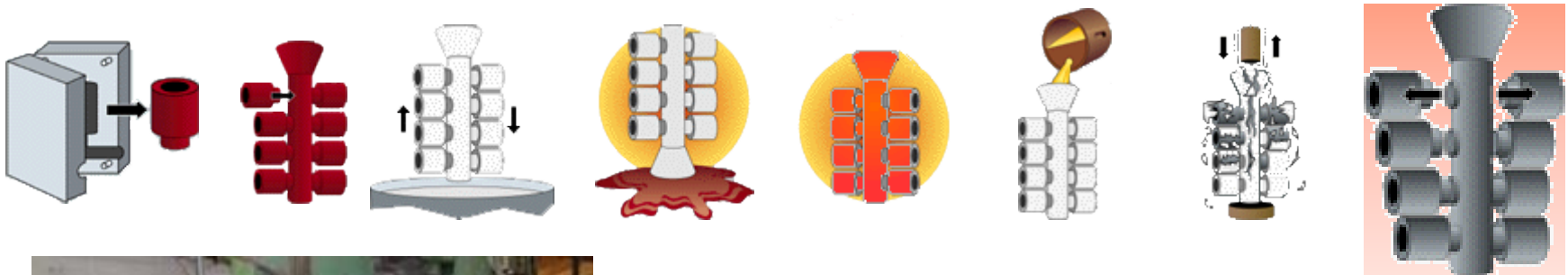
## Step 7: Remove Ceramic Shell from solidified metal



Removing Ceramic with Water Blast

# Investment Casting Process

## Step 8: Separate Castings from runner system



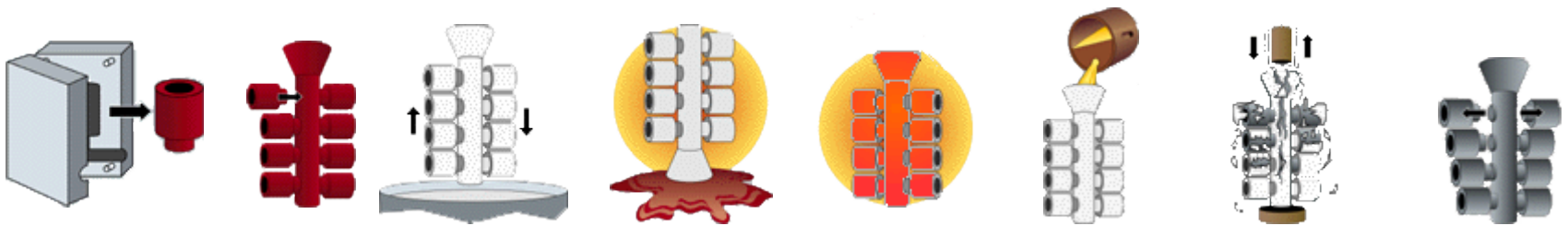
Cut-off operation with band saw

Gate Grinding



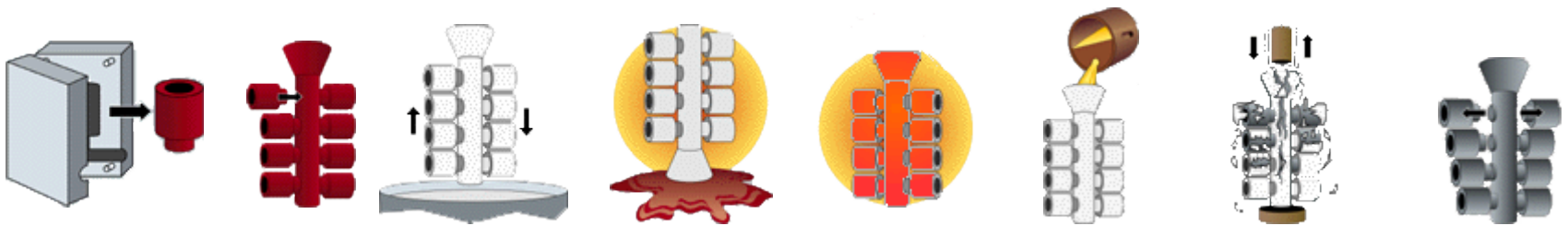
# Investment Casting Process

With Aluminum castings there are additional operations:



# Investment Casting Process

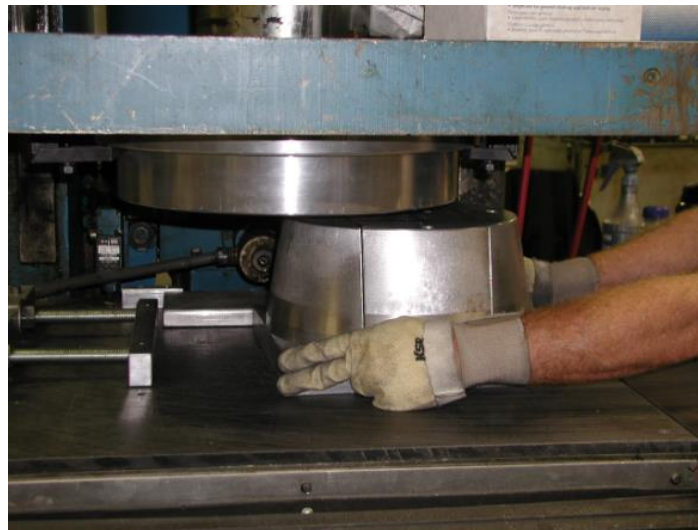
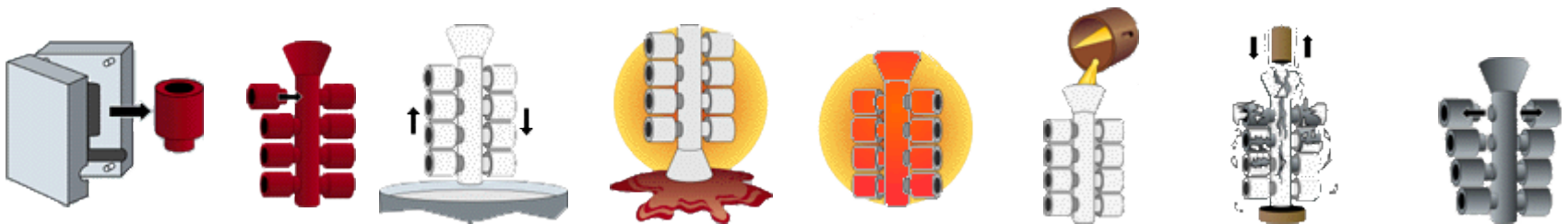
## ∞ Solution Anneal (T4)



Anneal Oven & Quench Tank

# Investment Casting Process

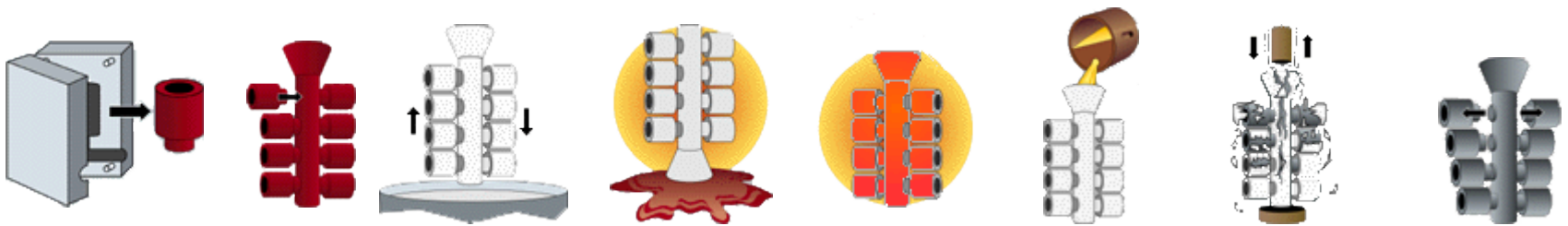
## Restore Straightness



Straightening

# Investment Casting Process

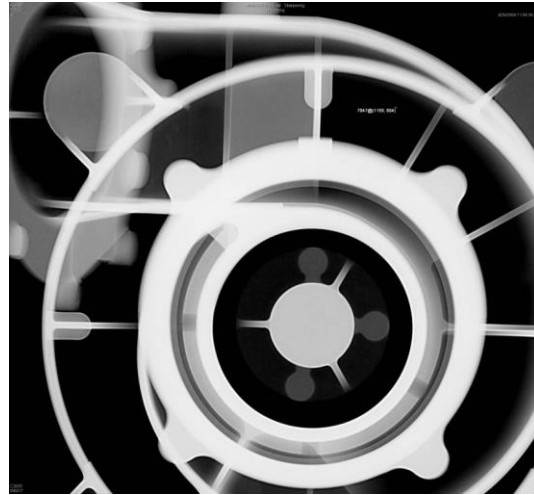
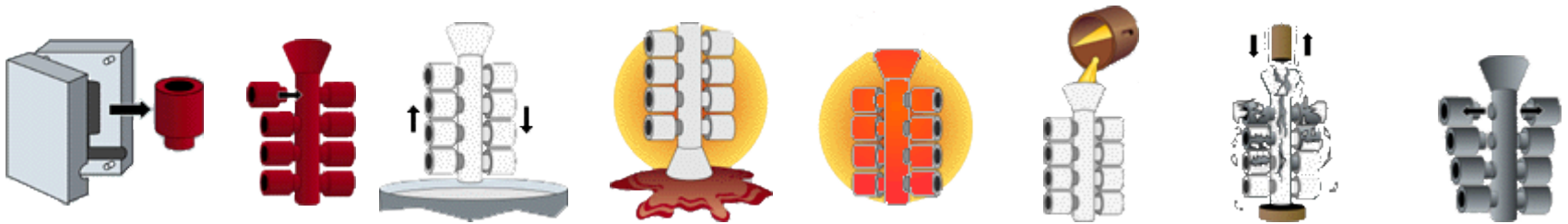
## Artificial Aging (T6)



Heat Treat Oven

# Investment Casting Process

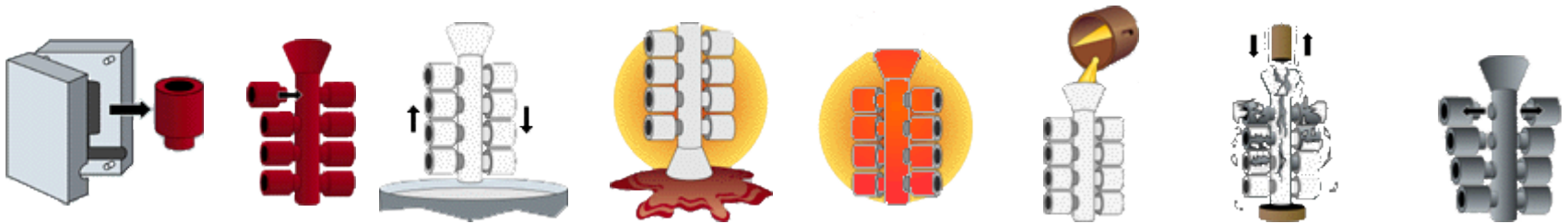
## Final Inspection



X-Ray Image (digital)

# Investment Casting Process

∞ Eight basic steps to Manufacture an Investment Casting



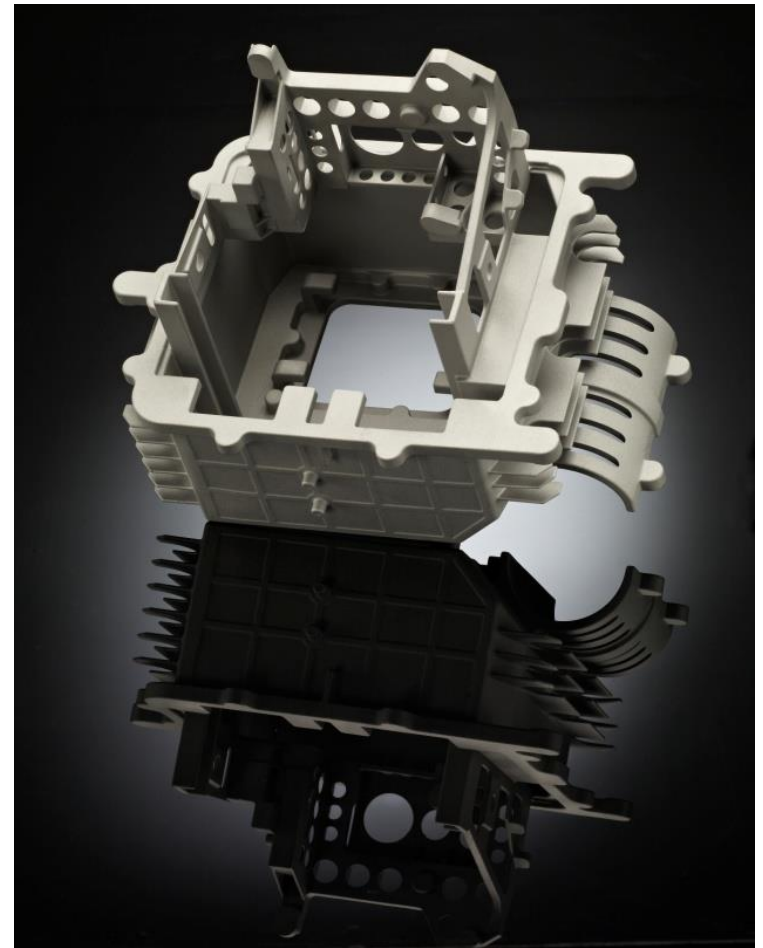
For the majority of process steps  
Investment Castings are handled as  
SPRUES and not as individual PARTS.

Process is less sensitive to part  
configuration



# Investment Casting Strengths

- ∞ **Complexity at Incremental Cost**
  - Combine multiple pieces into one
  - Reproduce fine detail
    - Contours and rounded surfaces
    - Undercuts
  
- ∞ **Near Net Shape**
  - Minimize secondary operations
  - Minimal stock allowance
  
- ∞ **Design Freedom**
  - No draft angle
  - Internal configuration
  
- ∞ **Low Initial Investment**
  - Moderate tooling costs



American Foundry Society  
2013 – “Casting of the Year”

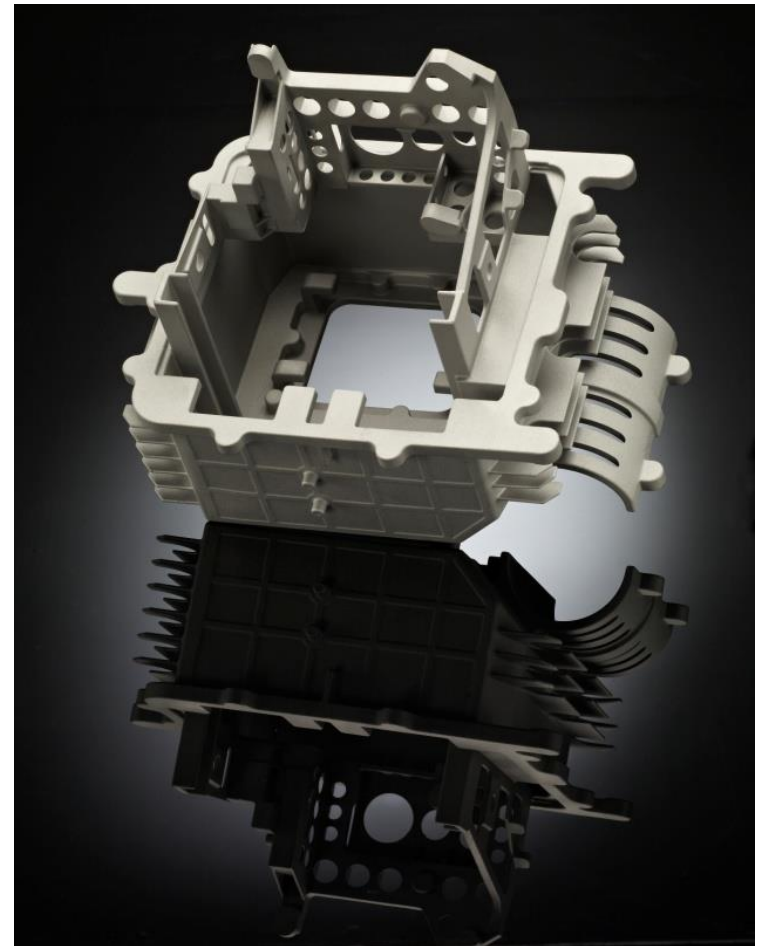
# Investment Casting Weaknesses

## ∞ Multiple Process Steps

- More Labor Intensive Process
- Higher per Unit Cost

## ∞ Long Cycle Time

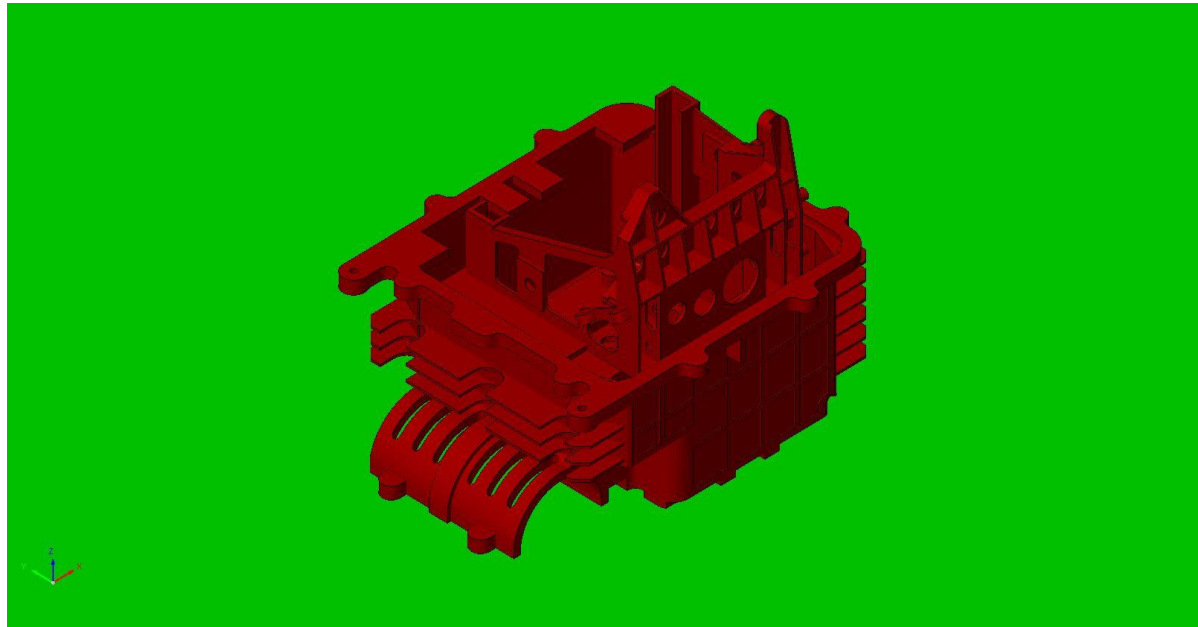
- Approximately 3-weeks from pattern injection to shipping



American Foundry Society  
2013 – “Casting of the Year”

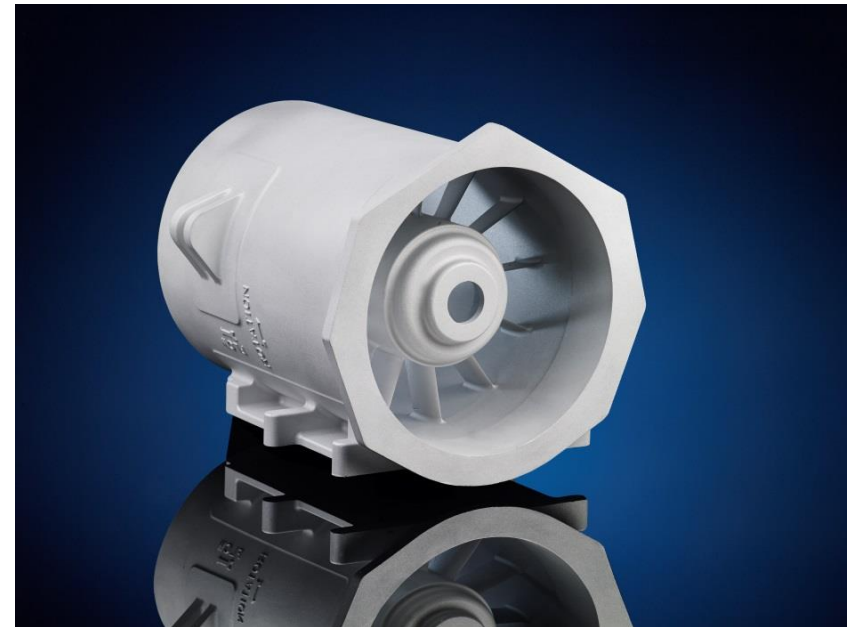
# The Design Engineer's Role

## Characteristics of Investment Casting



# Characteristics of a Potential Investment Casting

- ☞ Alloy Machinability
  - Near Net Shape
  - Reduced Secondary Machining
- ☞ Eliminate Assembly & Fabrication
  - Reduction of Part Count
- ☞ Light Weight
  - Optimum wall .070 - .120"
- ☞ Cosmetic Appearance
  - 60 – 200 RMS
- ☞ Precision Tolerances
  - $\pm$ .005 inch per inch



2014 – AFS/MCDP Casting of the Year - Honorable Mention

# Typical Nonferrous Applications

## ∞ Electronic Boxes & Chassis

- Part Count Reduction



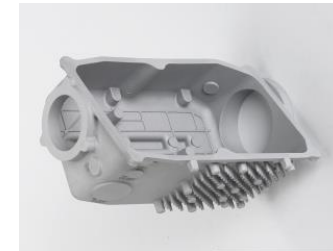
## ∞ Fluid Flow

- Near Net Shape



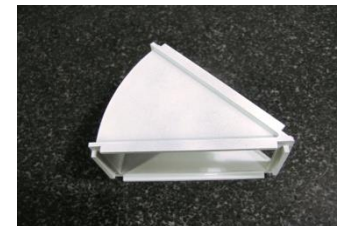
## ∞ Optics Housings

- Thin wall to reduce weight



## ∞ Microwave Bends

- Near Net Shape



# Investment Casting Cost Drivers

## ∞ Size of Part

- Determines the number of parts per sprue

## ∞ Configuration of Part

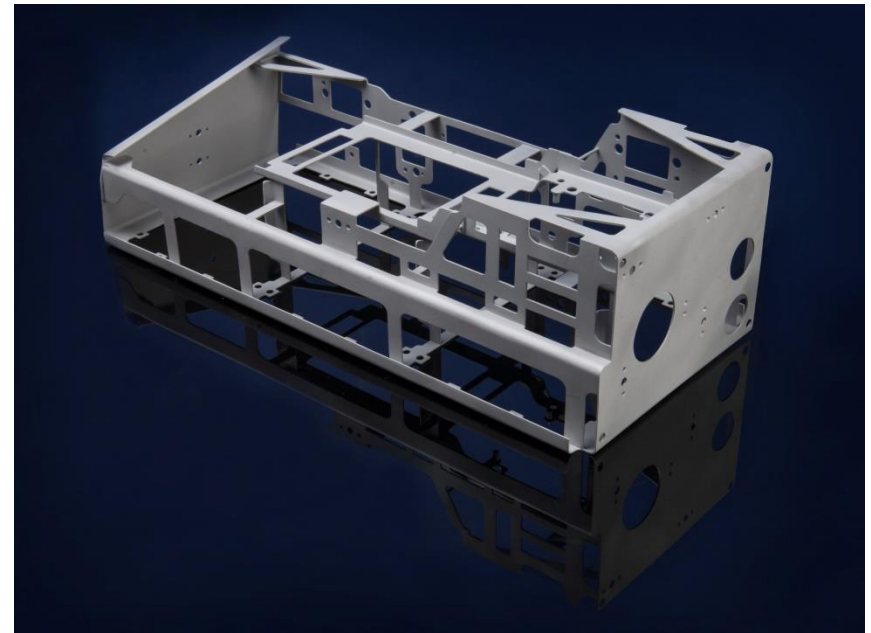
- Drives the number of gates
- Contributes to scrap & rework

## ∞ Inspection Requirements

- Radiography
- Physical Property Testing

## ∞ Premium Tolerances

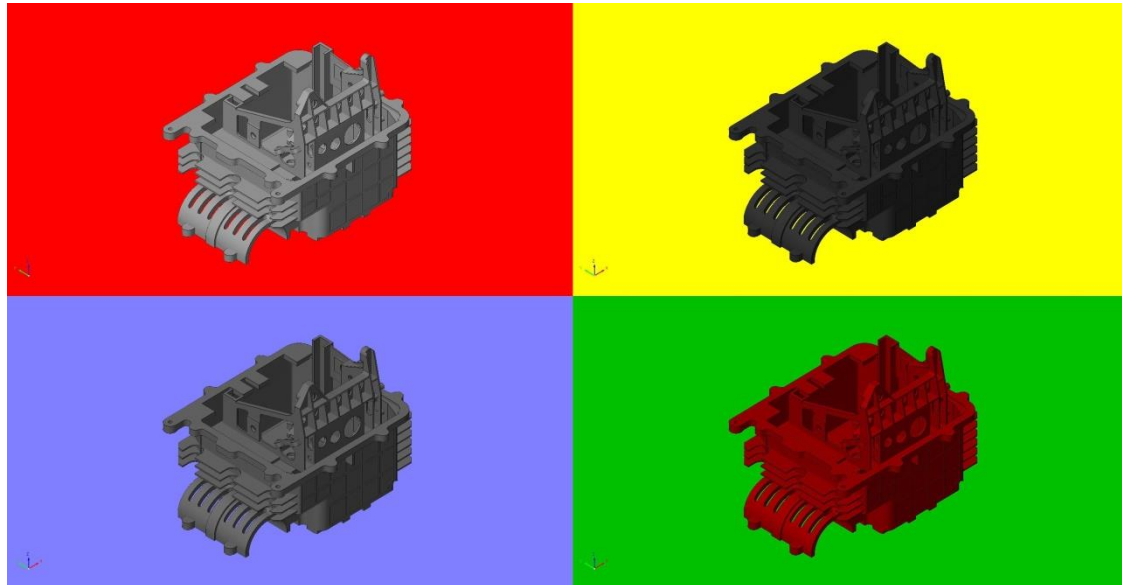
- Can Increase labor content



2014 – ICI Aerospace Casting of the Year

# The Design Engineer's Role

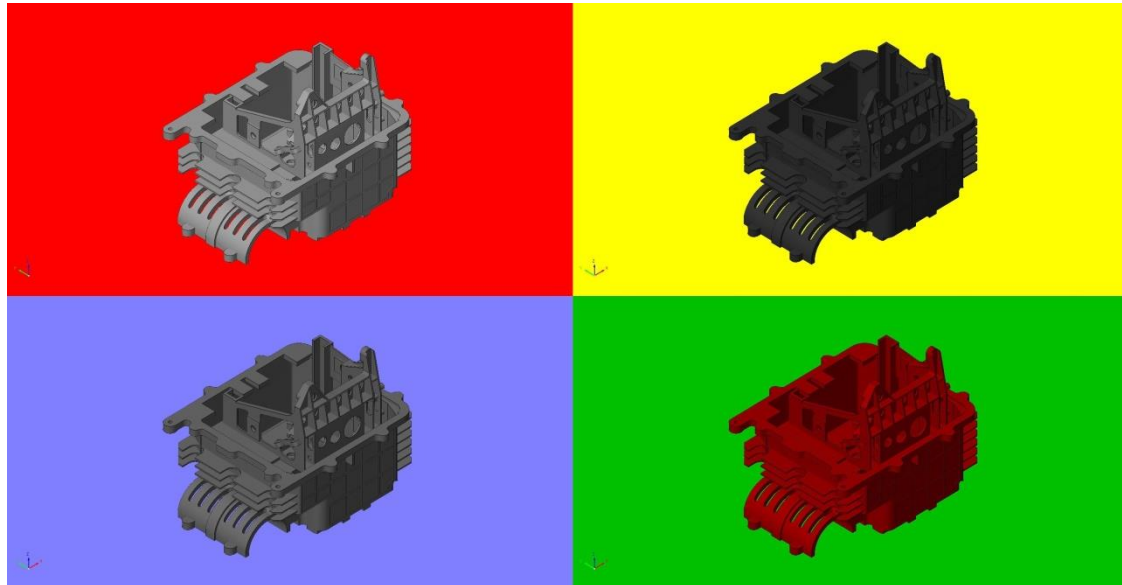
70 – 95% of total Product Cost is the result of Design Decisions.



# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability      Manufactured with predictable yields?



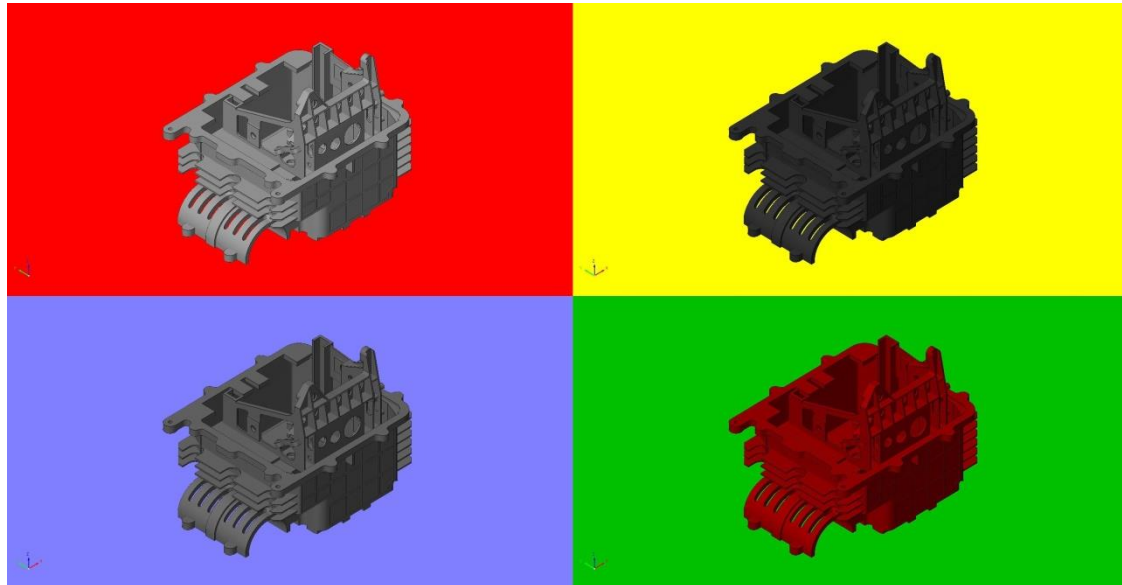


# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability

Can the product be delivered when you need it?

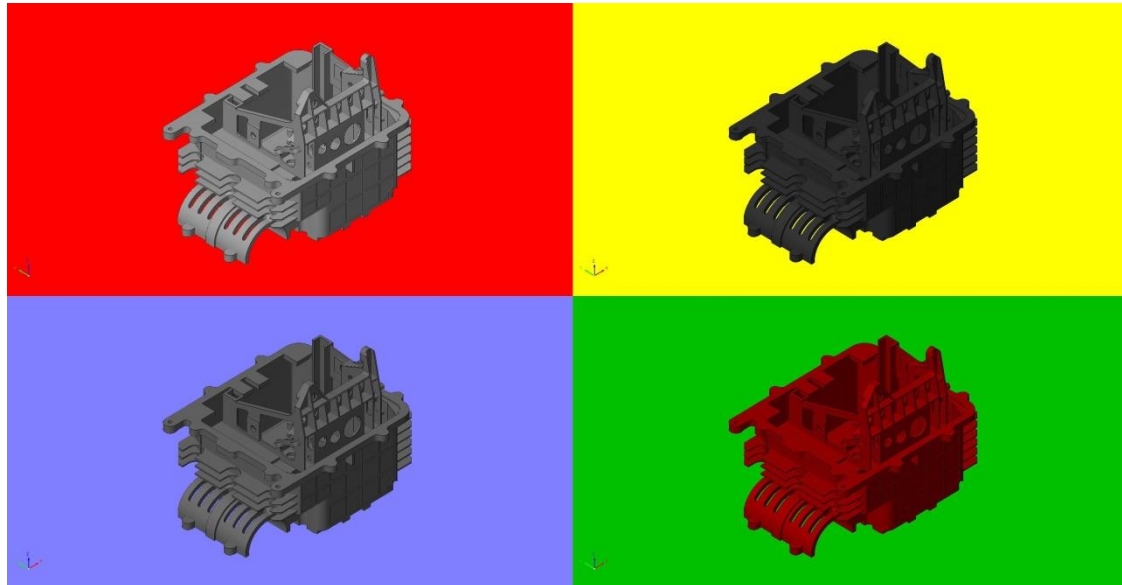


# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability
- Reliability

Is the product “Good” when you receive it?

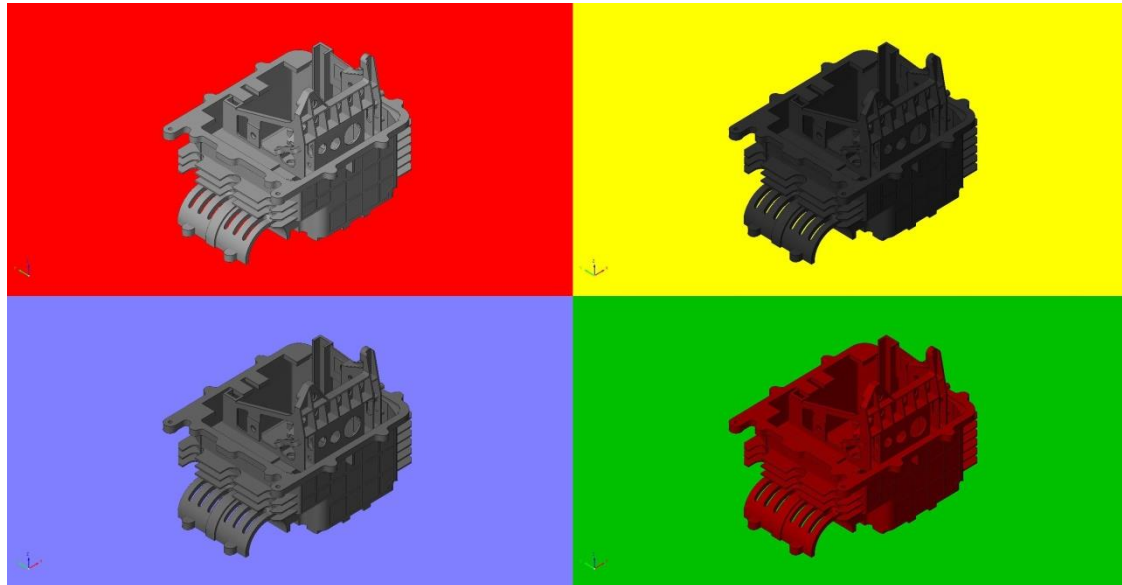


# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability
- Reliability
- Inventory

Did you receive all the needed parts for the assembly?

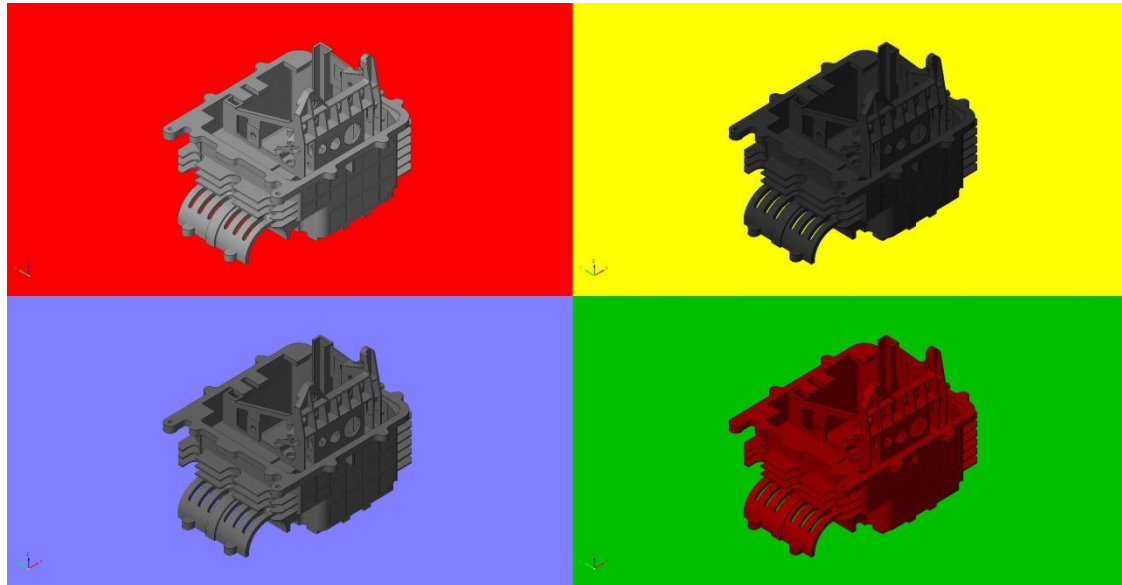


# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability
- Reliability
- Inventory
- Administrative costs

The costs of shortages & rejects?

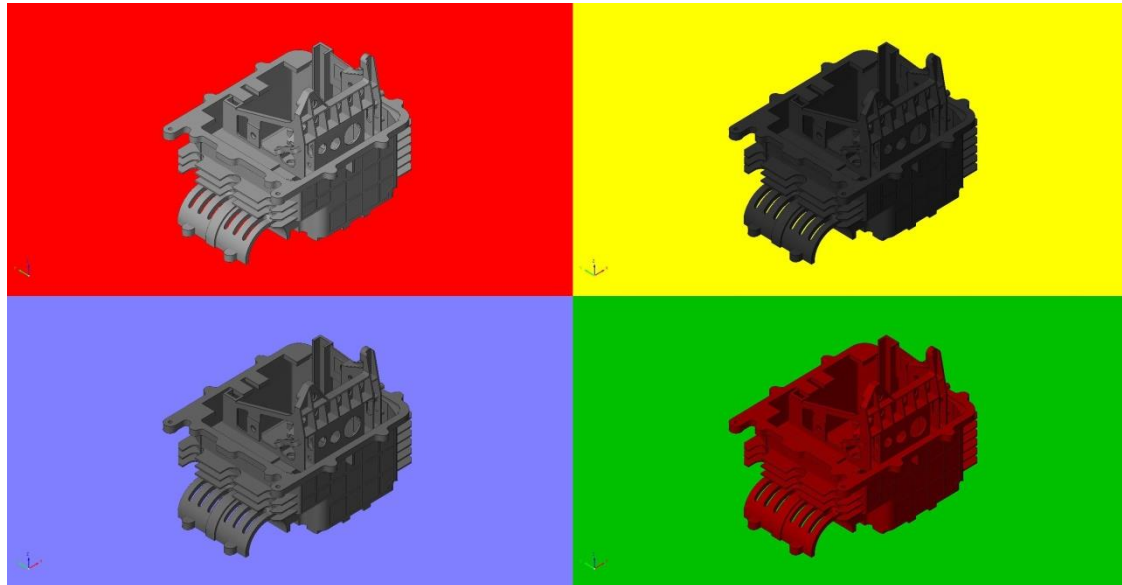


# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability
- Reliability
- Inventory
- Administrative costs
- **Affordability**

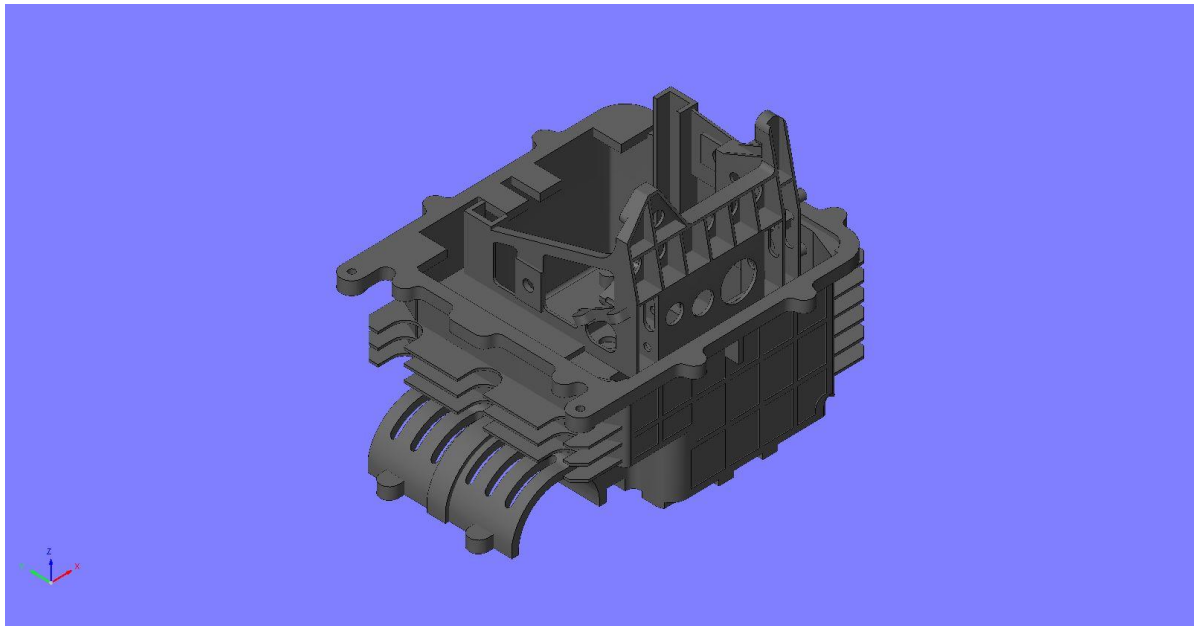
Excess costs effect your price, profit and reputation.



# The Design Engineer's Role

## ∞ The High Cost of Part Count

- The fewer parts - the more Affordable an engineered Assembly



# The Design Engineer's Role

Castings, and in particular Investment Castings, are an effective method to reduce the total Part Count of an engineered assembly.

## ∞ Part Design

- Checking & Approval
- Document & Data Control
- Make / Buy Decision

## ∞ Procurement

- Requisitions
- Purchase Orders
- Expedites
- Surveillance

## ∞ Manufacturing

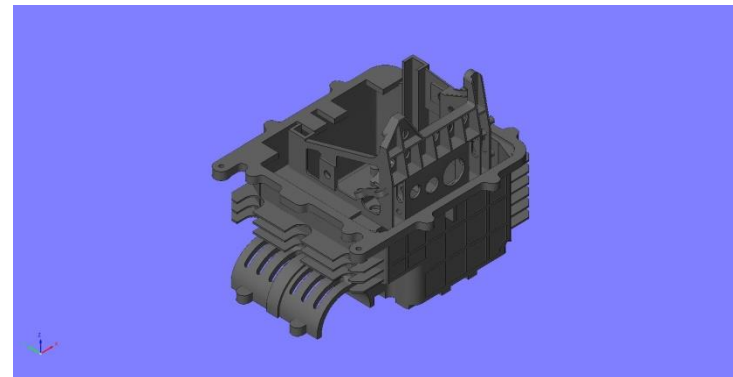
- Tooling
- Planning
- Inspection

## ∞ Receiving

- Incoming Inspection
- Shipping & Receiving
- Inventory
- Cost of Quality

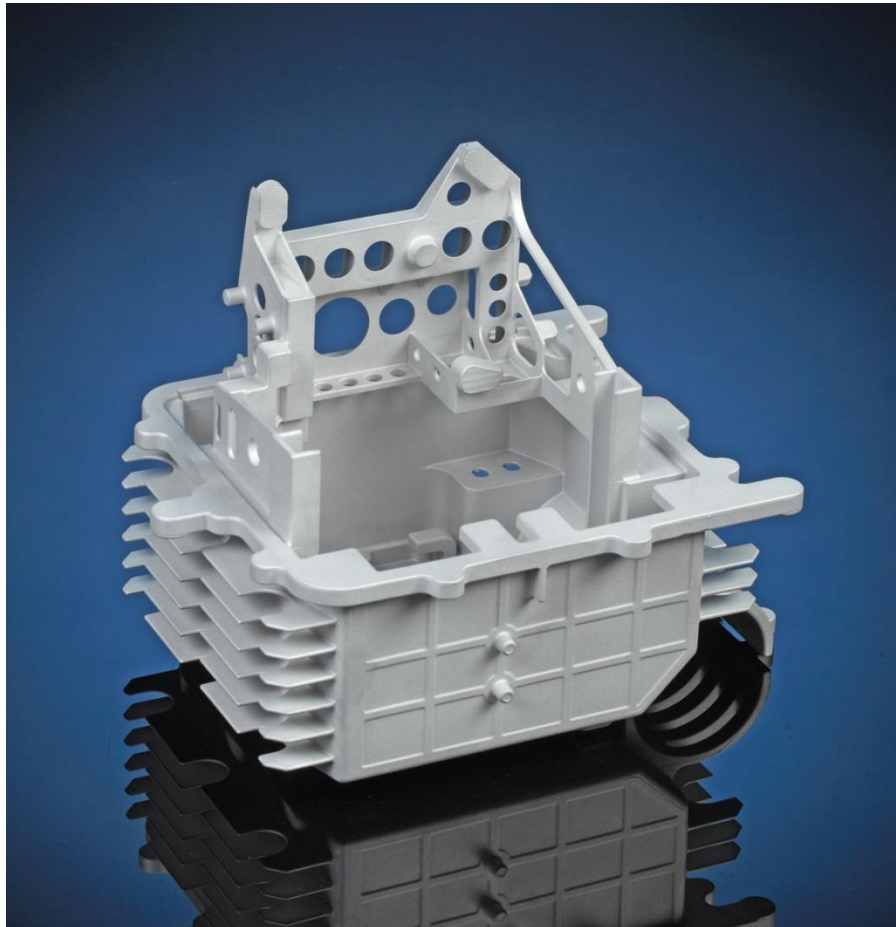
## ∞ Assembly

- Risks of Assembly failure
- Warranty costs



# The Design Engineer's Role

AFS / MCDP – 2013 Casting of the Year

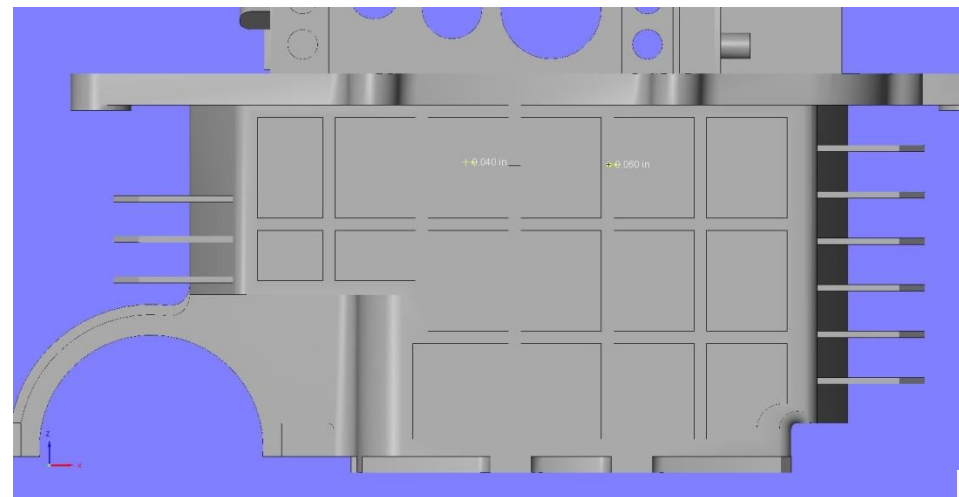
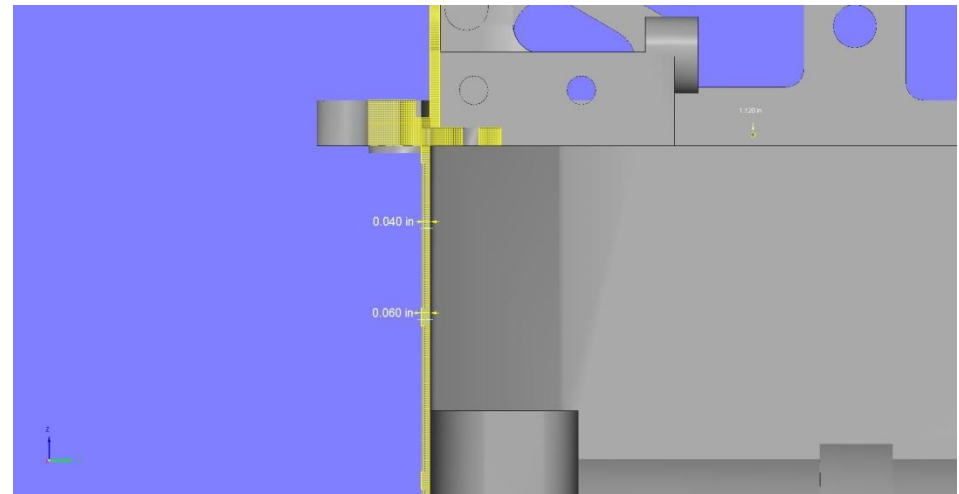




# AFS / MCDP 2013 Casting of the Year

## Lightweight

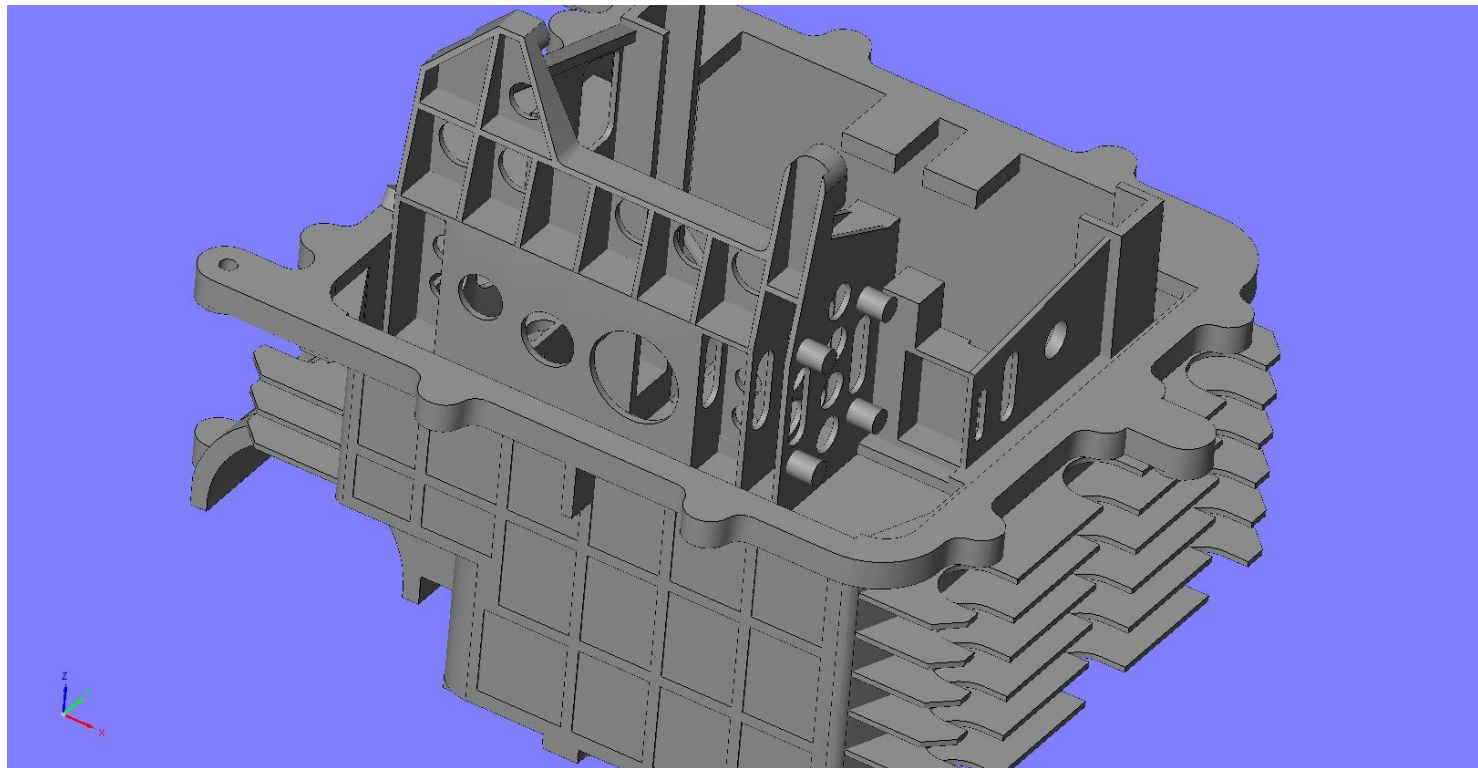
- 7.5" x 7.5" x 10"
- 20 Ounces
- .040 Wall Thickness
- .060 Ribs for Stiffness



# AFS / MCDP 2013 Casting of the Year

## Lightweight

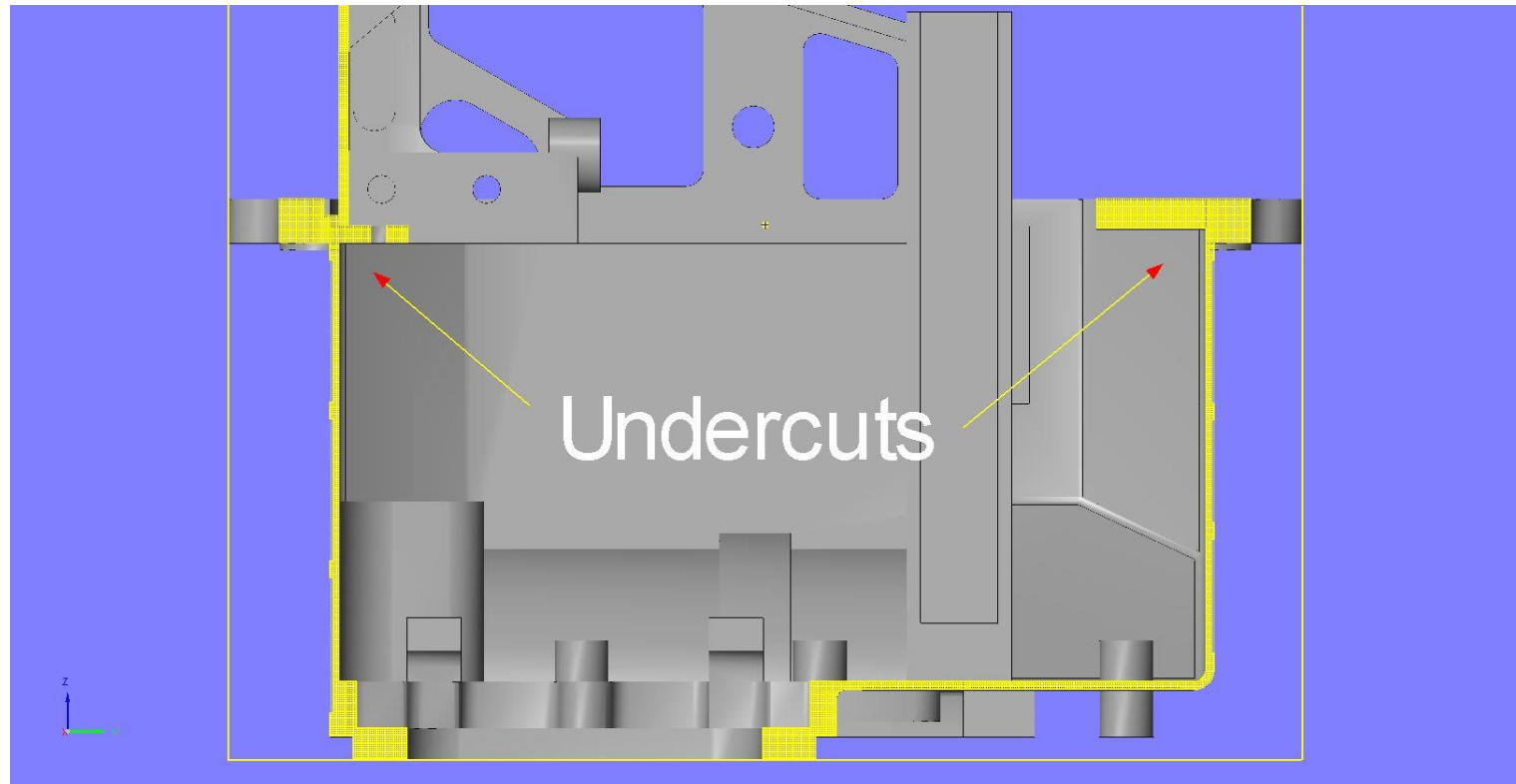
- Lightening Pockets
- Lightening Holes & Slots



# AFS / MCDP 2013 Casting of the Year

## Lightweight

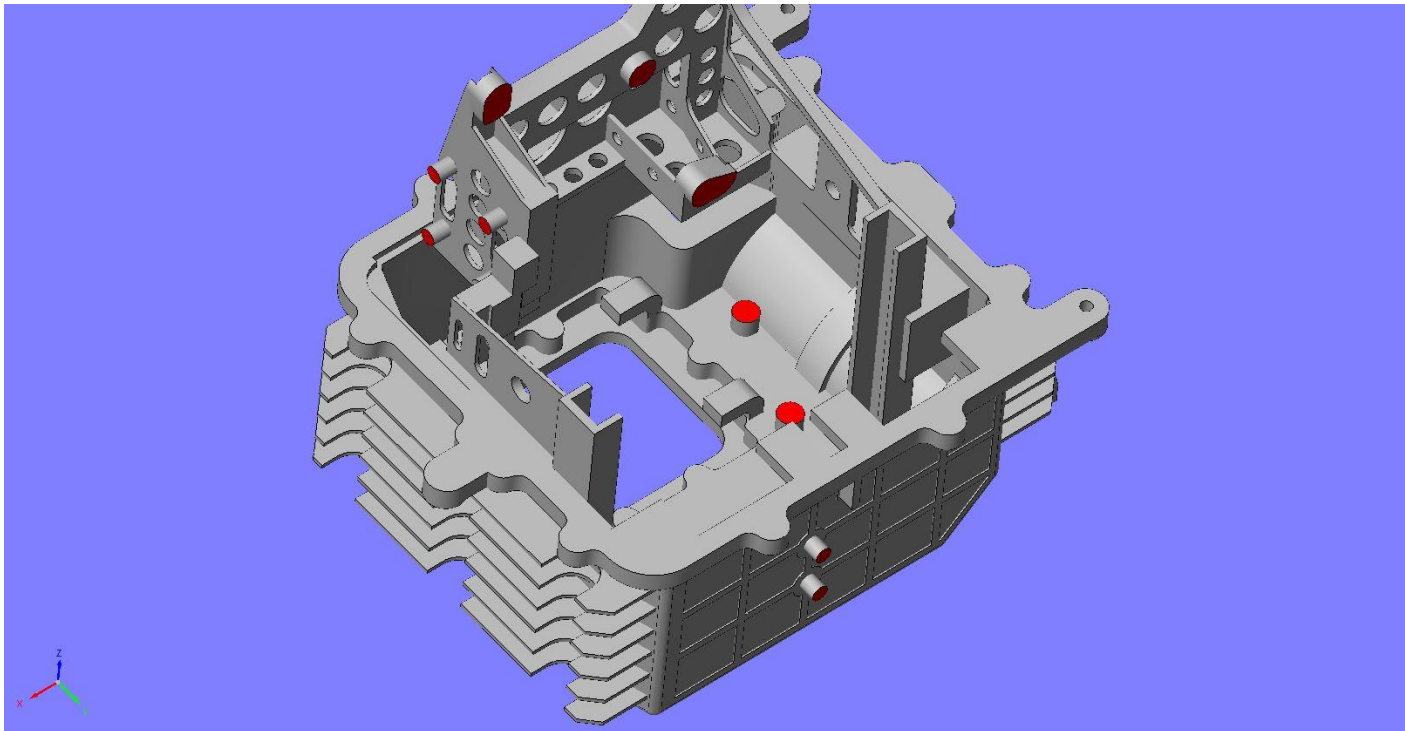
- Undercuts



# AFS / MCDP 2013 Casting of the Year

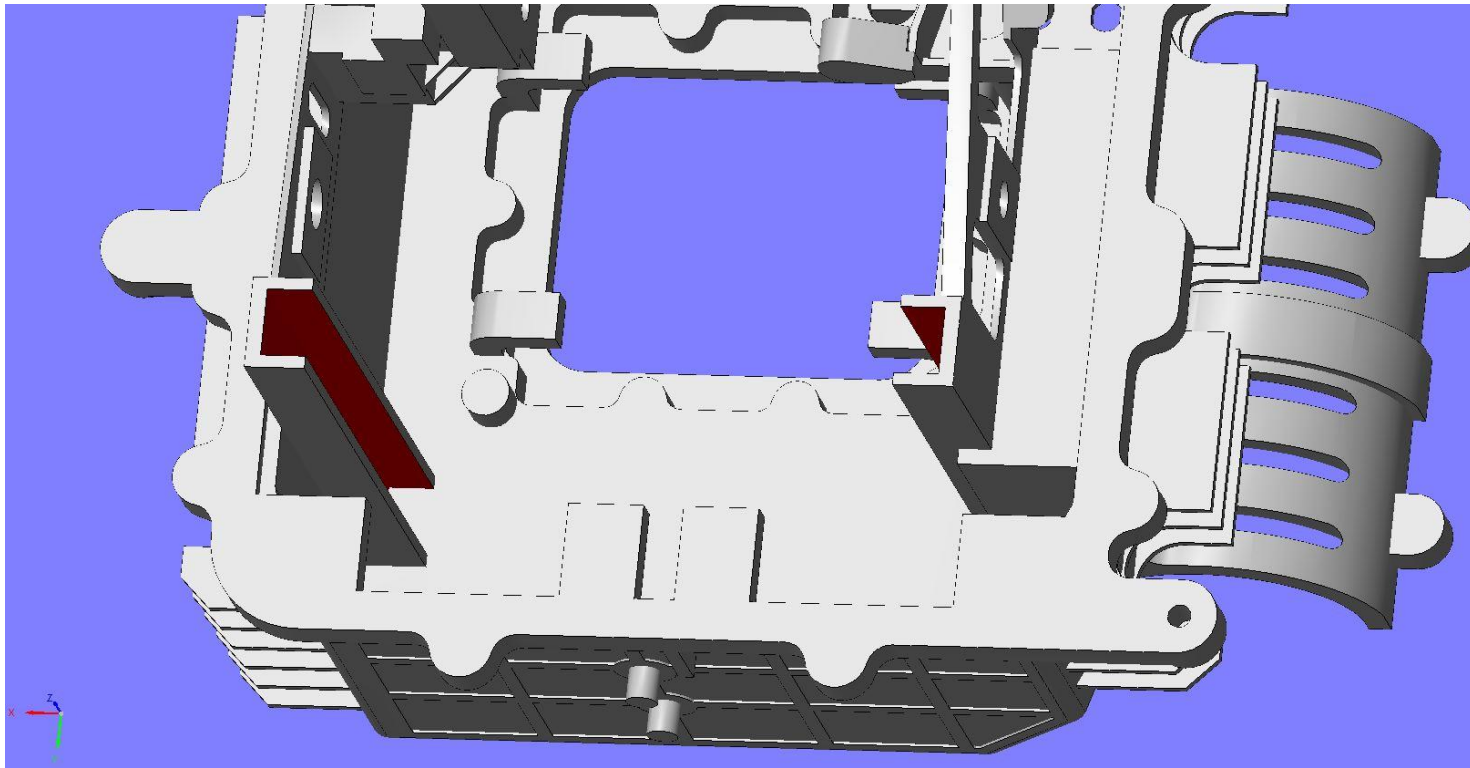
## ∞ Reduced Part Count

- Mounting Bosses – raised
- Minimizes Secondary Machining



# AFS / MCDP 2013 Casting of the Year

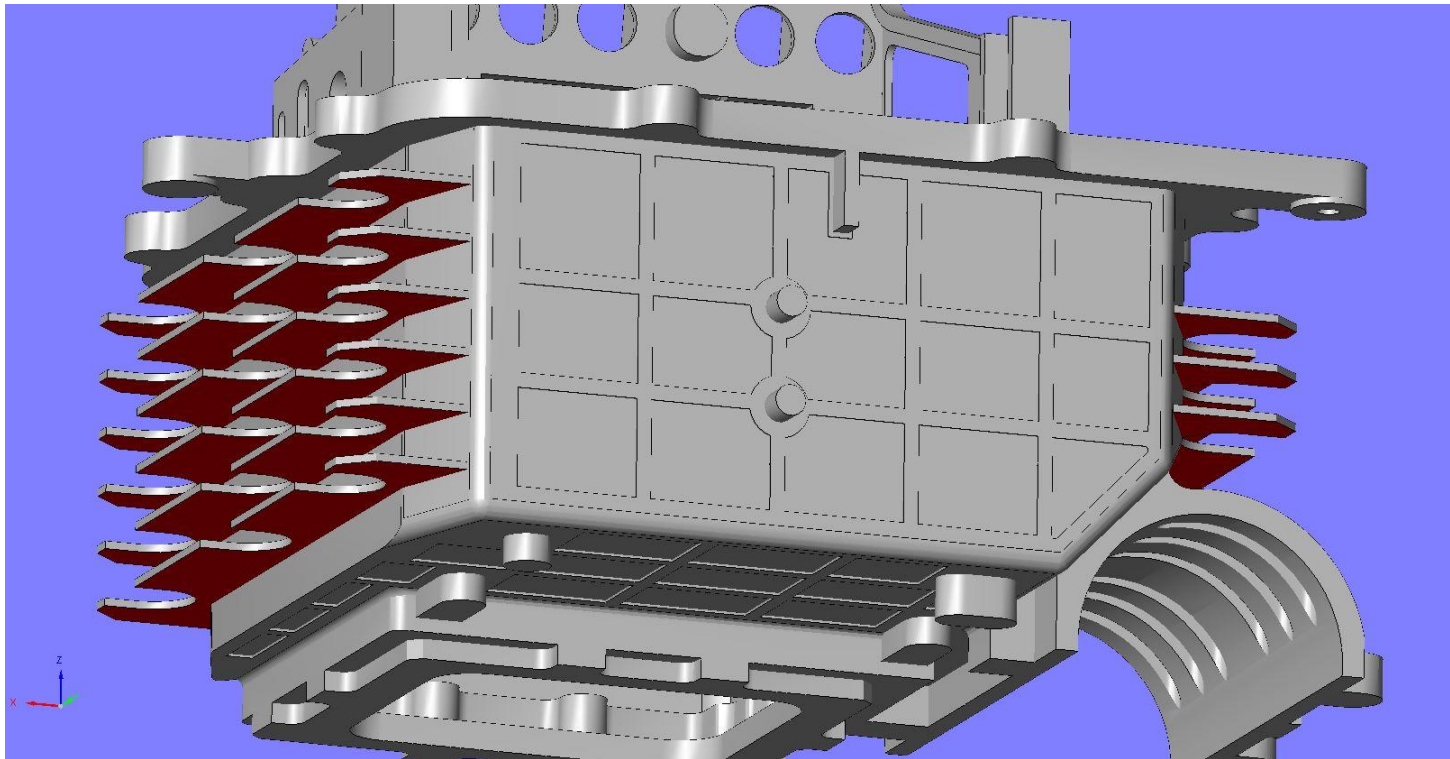
- ∞ Reduced Part Count
  - Card Guide Slots



# AFS / MCDP 2013 Casting of the Year

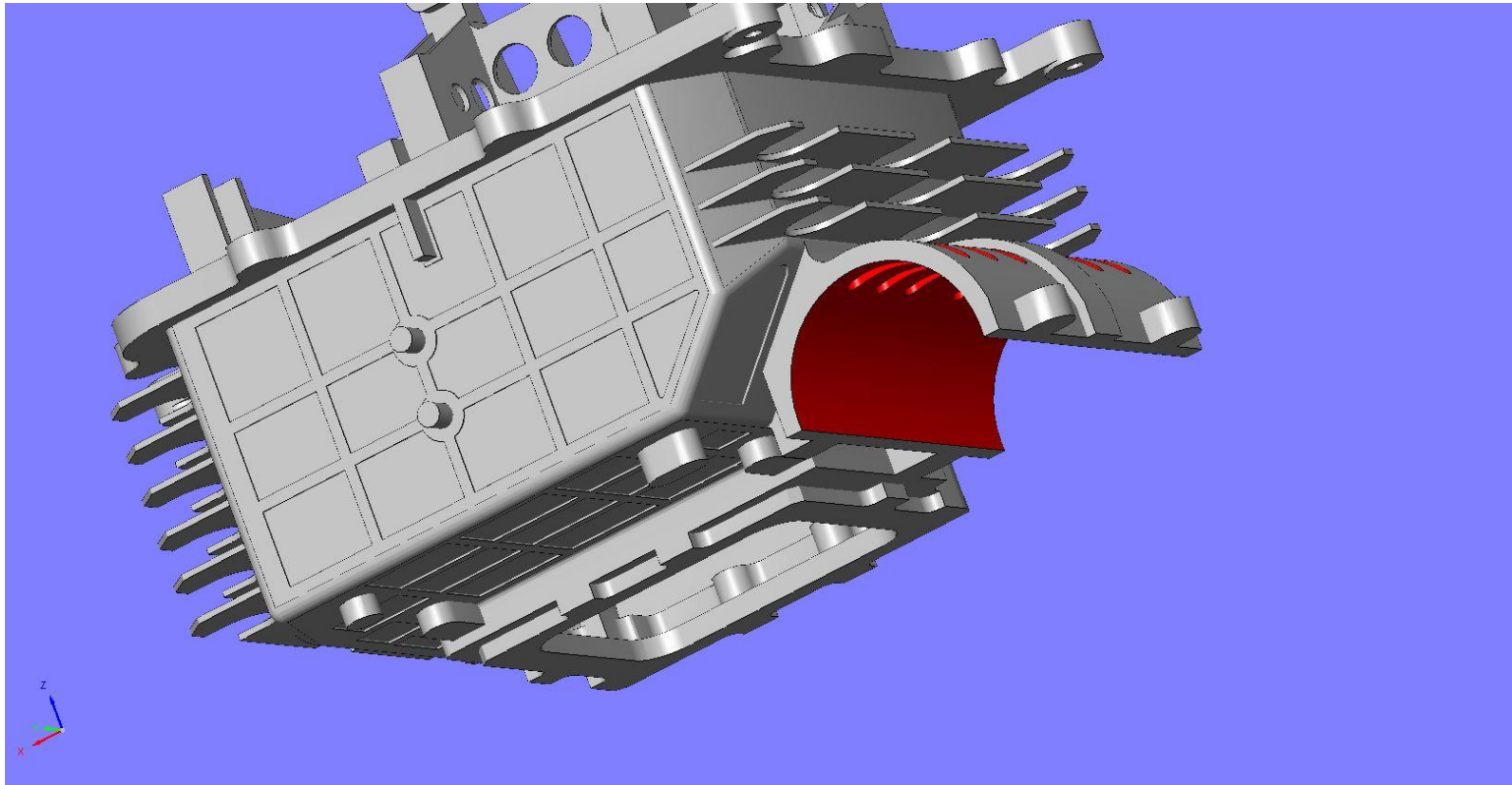
## ∞ Reduced Part Count

- Heat Sink Fins
  - Includes Clearance for wrench access



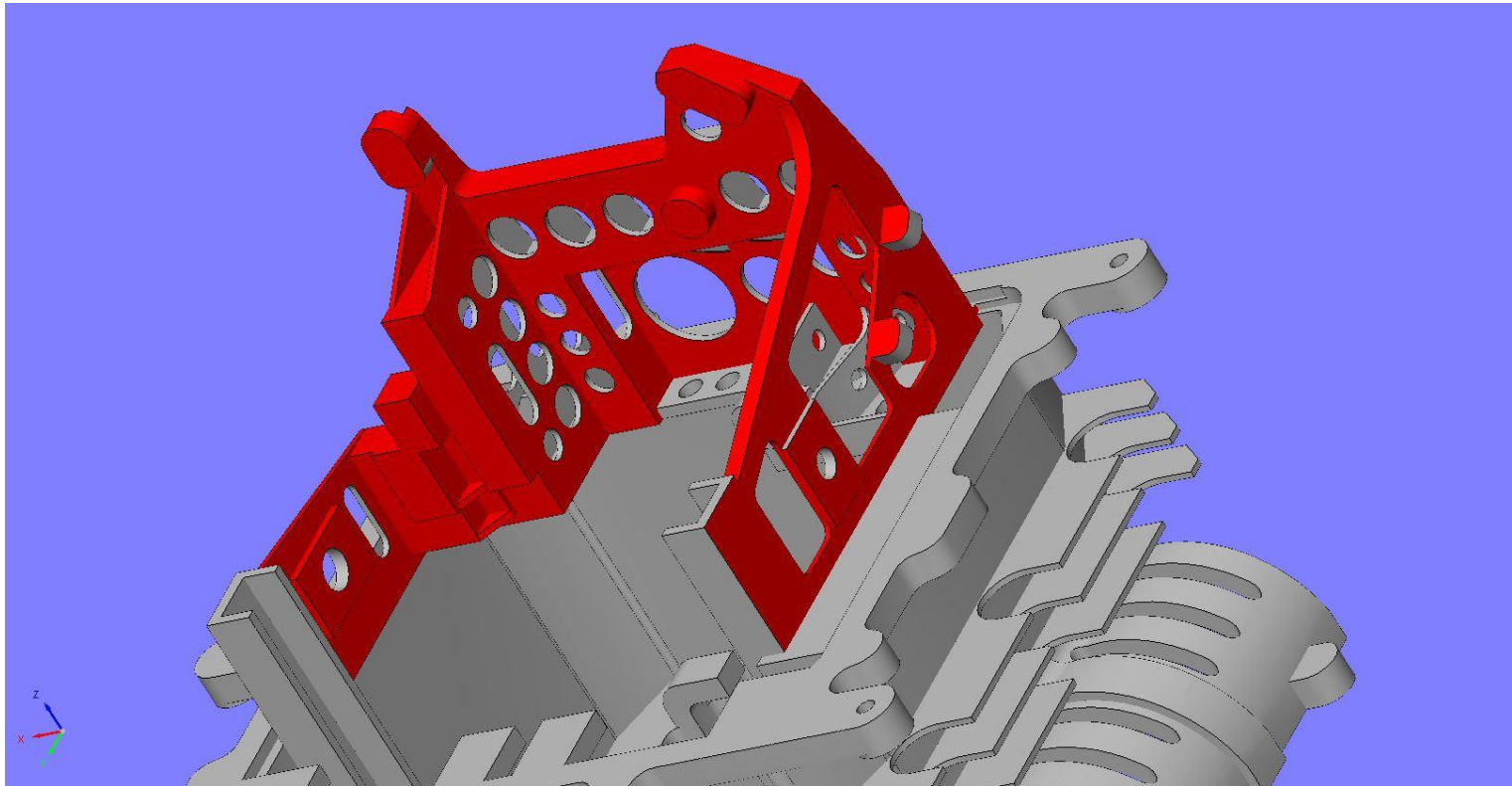
# AFS / MCDP 2013 Casting of the Year

- ∞ Reduced Part Count
  - Pole Mount Clamp Half



# AFS / MCDP 2013 Casting of the Year

- ∞ Reduced Part Count
  - Superstructure

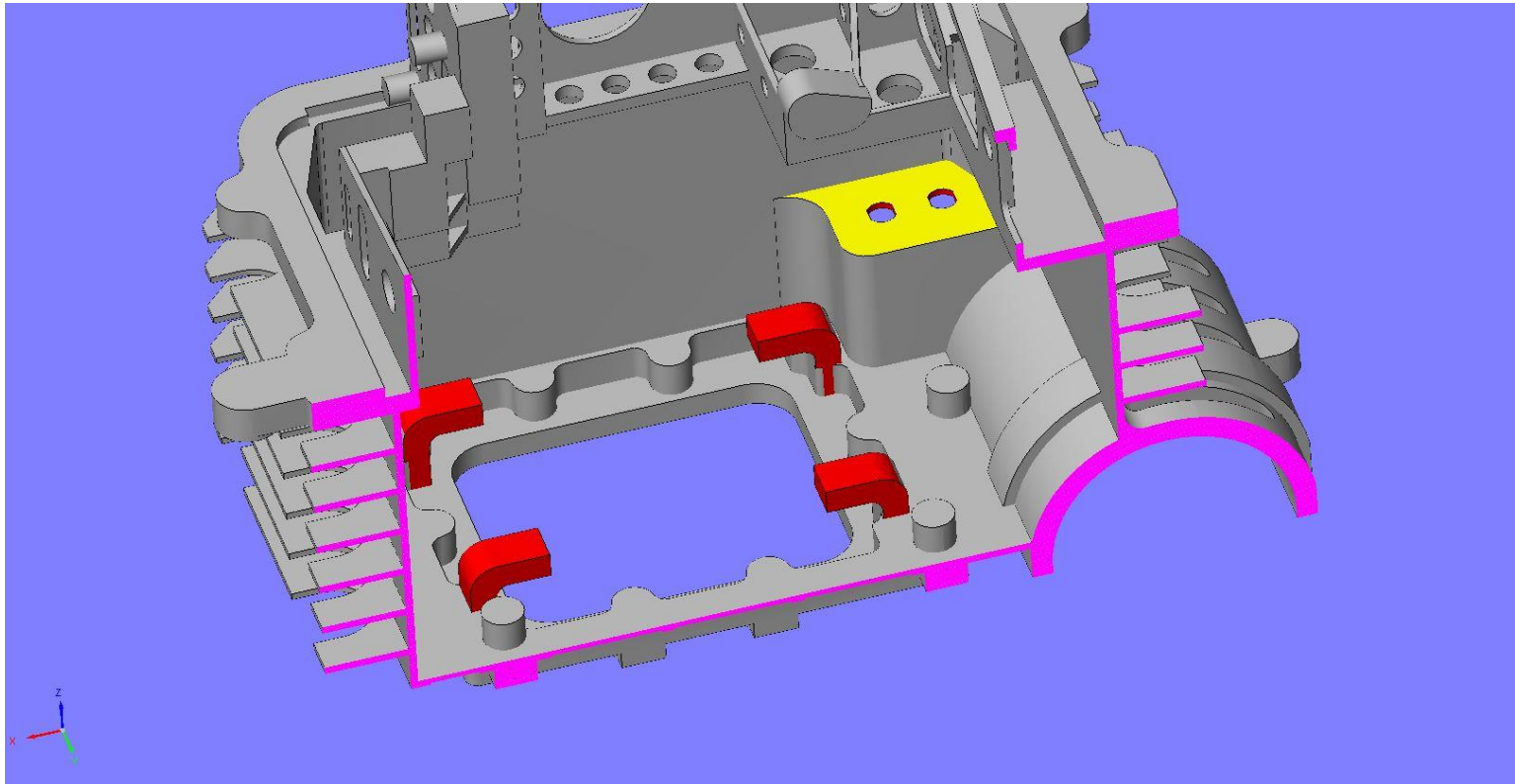




# AFS / MCDP 2013 Casting of the Year

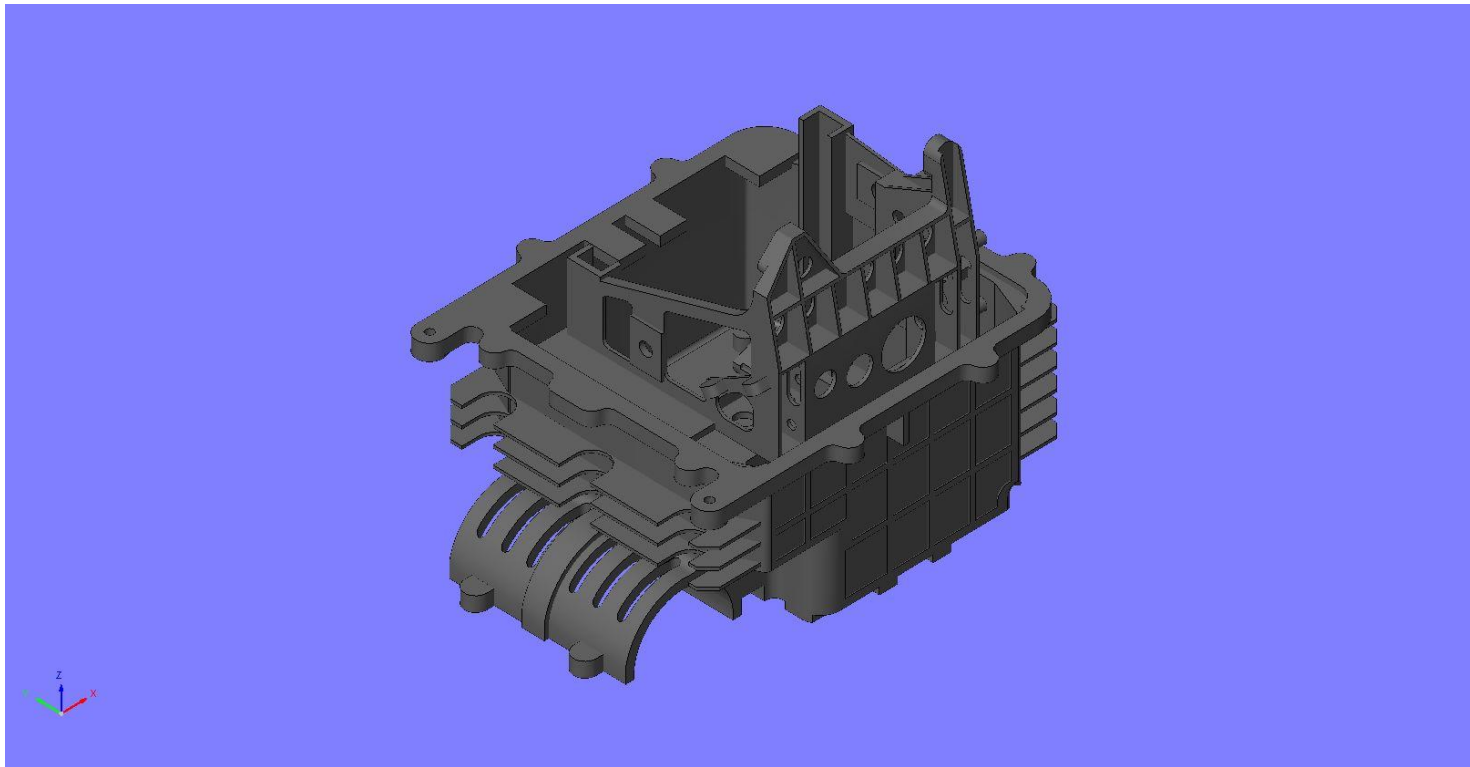
## ∞ Reduced Part Count

- (4) Mounting Hooks & Double “D” Holes



# The Design Engineer's Role

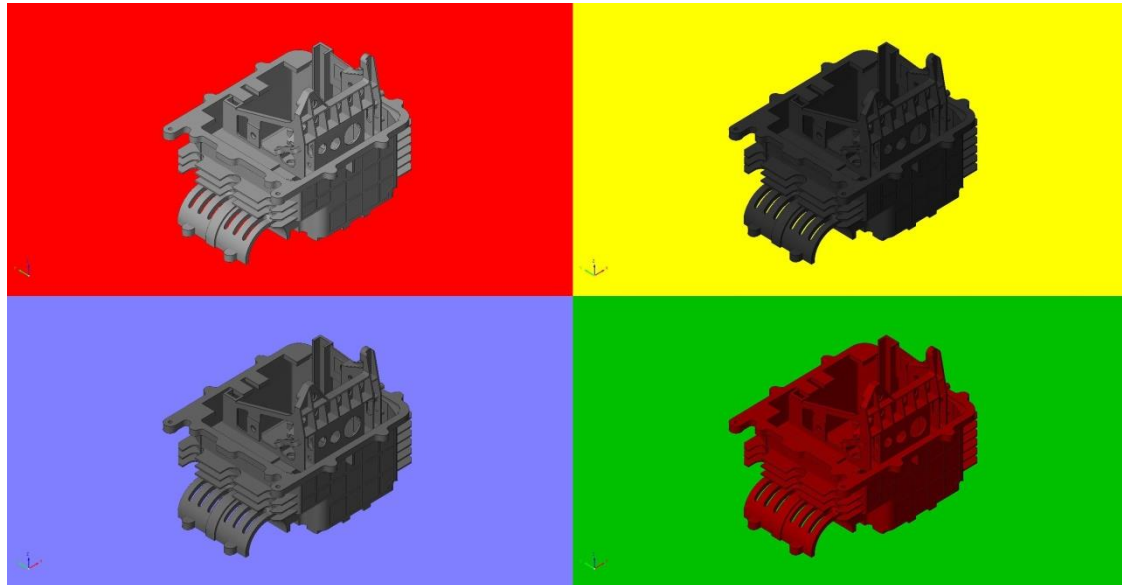
## ∞ Lessons Learned



# The Design Engineer's Role

70 – 95% of total Product Cost is the result of Design Decisions.

- Manufacturability
- Availability
- Reliability
- Inventory
- Administrative costs
- **Affordability**



# The Design Engineer's Role

## ∞ Castings are Custom Products

- Have only one purpose for one customer
- Require a Specialized Expertise

## ∞ Grow your Internal Specialized Expertise

- Engineering
- Quality
- Procurement

## ∞ Develop Understanding of External Processes

- Good Design Practices for each process
- Strengths & Weaknesses of competing processes



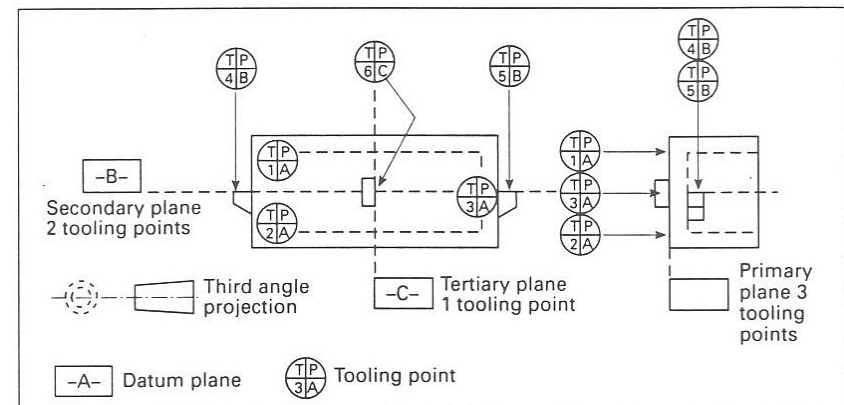
# The Design Engineer's Role

## Utilize good casting design practices

- Adequate fillet radii
- Reasonable tolerances
- Datums & Datum Points

## Good Design improves casting Producability

- Predictable casting yields
- Stabilizes Price
- Improves Delivery Performance
- Consistent Product Quality
  - Fewer rejections
  - Fewer engineer changes



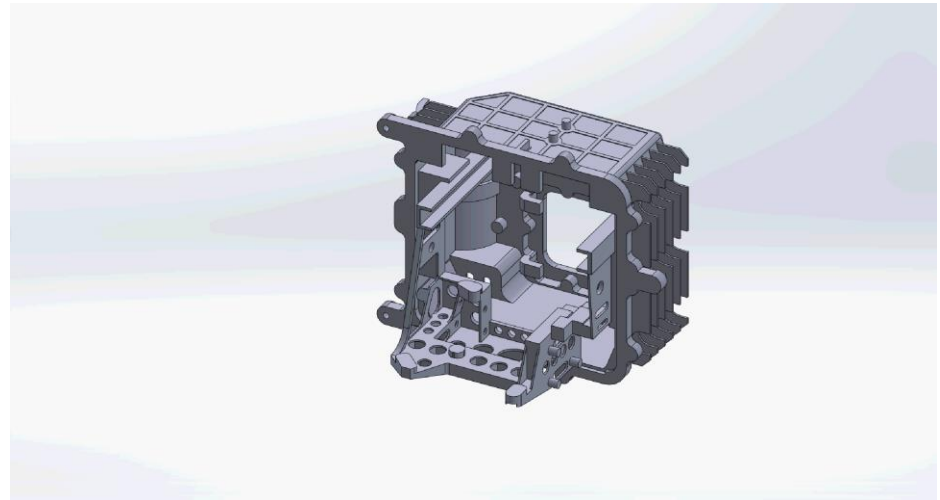
# The Design Engineer's Role

## ∞ Design for Higher Levels of Complexity

- Complexity cost is largely reflected only in tooling & at pattern injection
- Part Count Reduction - Combine multiple piece structure
- Reduce secondary operations
- Reduce assembly operations

## ∞ Near-Net-Shape Design

- Machine only Critical Features



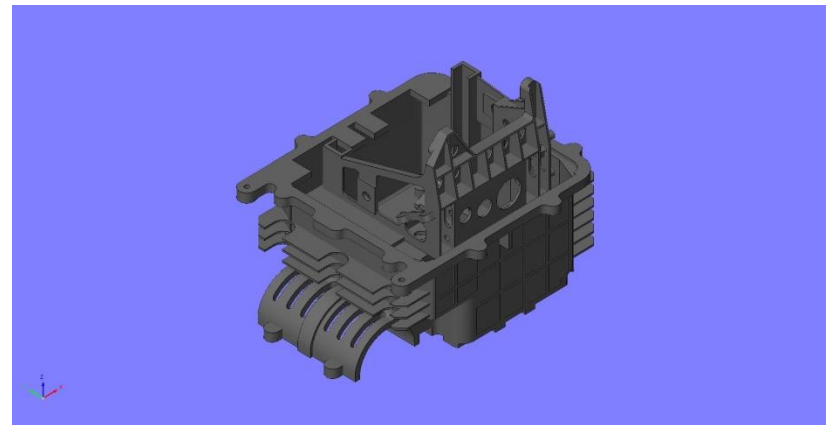
# The Design Engineer's Role

## ∞ Embrace Concurrent Engineering

- Supplier Involvement early design
  - Opportunity to combine parts and Reduce Part Count of Assemblies
  - Avoid unnecessary Designed-In cost
- Solicit design feedback from Supply Base

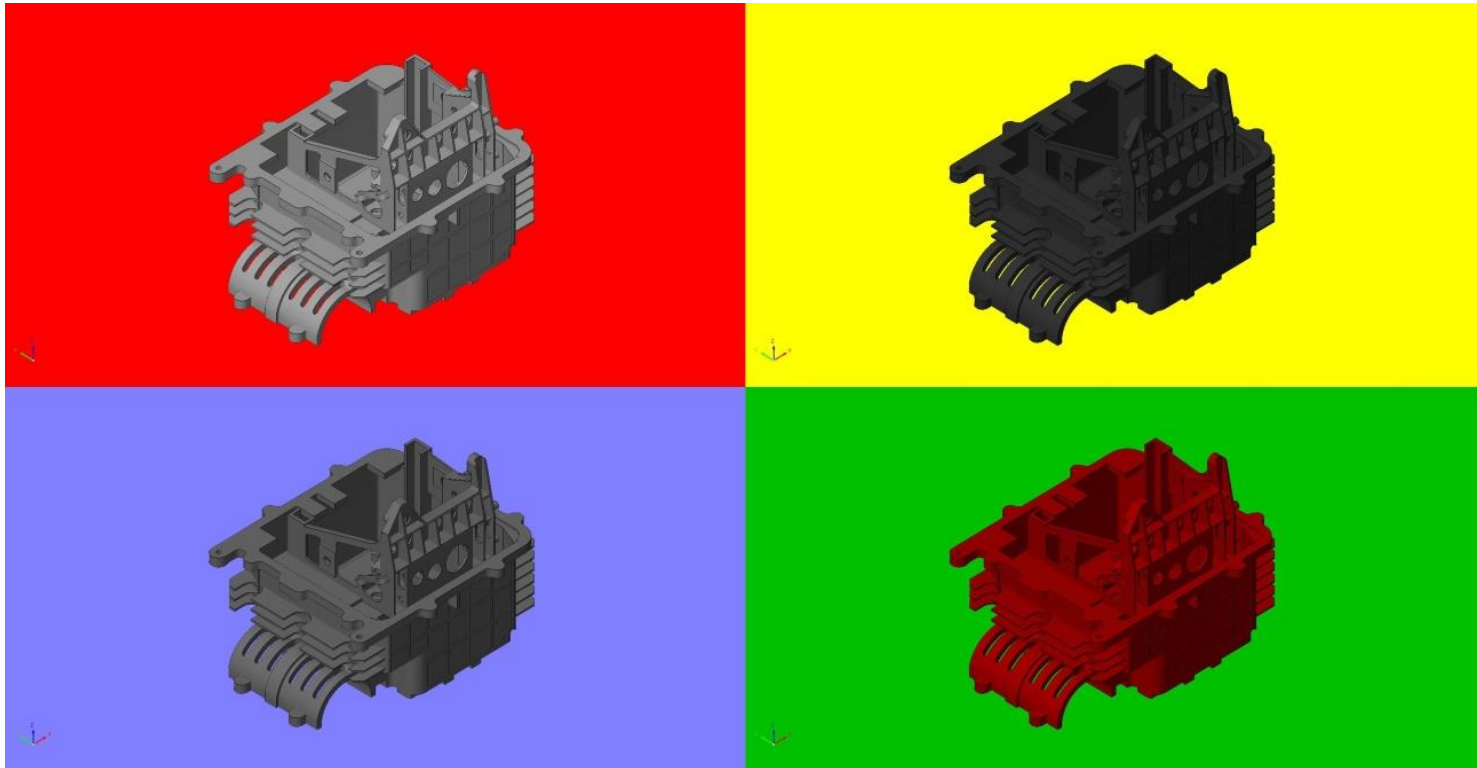
## ∞ Vendor & Industry Provided Educational Opportunities

- Concurrent Engineering
- IC-101
- IC-201



# The Design Engineer's Role

∞ Thank You!





# Contact



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O'Fallon, MO 63366

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Fax: 636-272-6180

Email: [sales@ofalloncasting.com](mailto:sales@ofalloncasting.com)

Web: <http://www.ofalloncasting.com/>

YouTube: <http://www.youtube.com/watch?v=UEiuYo9L0Jk>  
<http://www.youtube.com/watch?v=IbNqipic0g4>

