

White Paper

# Additive Manufacturing Solutions for Investment Casting

Building new manufacturing efficiencies with 3D printed  
casting patterns and methodologies from 3D Systems

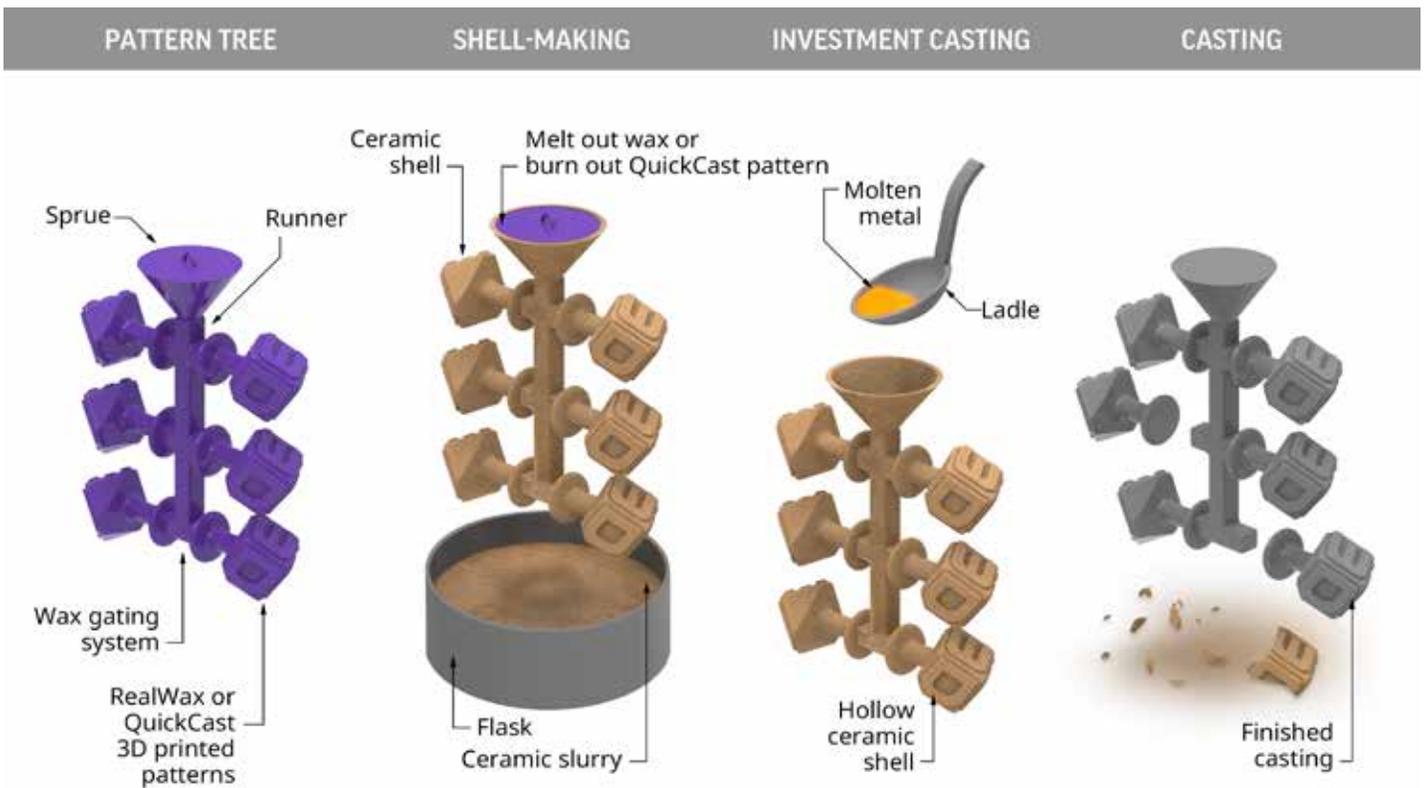


# Investment Casting in the 21st Century

Investment casting is an important manufacturing process with a history that is thousands of years old. Also known as lost wax and shell investment casting, the process of shaping molten metal into objects using wax patterns and ceramic molds is still used today. The process is commonly used for all kinds of mechanical parts; engine parts; gears; dental work; jewelry; turbine blades; and other objects requiring complex and exact geometries.

Investment casting is often used when extreme smoothness and accuracy are required, production quantities are low, and design complexity is high.

Investment casting is precise, but it is also time consuming and expensive. For example, for one customer the traditional method of using a wax injection tool to create an axial turbine blisk mold requires at least five weeks and can cost upwards of \$20,000 from start to finish. In comparison to traditional methods, the time and cost investments for 3D printed investment casting patterns are much lower, and 3D printing can also produce patterns of greater complexity. A typical 3D Systems customer can create a 3D printed investment pattern overnight; in the morning it is ready for the foundry at a cost of under \$2,000.



The investment casting process using 3D printed patterns

# Specific Benefits of 3D Printed Casting Patterns

3D printed casting patterns have enabled significantly more timely and cost-efficient production of casted parts. In direct comparisons between 3D printed casting patterns and traditional methods, customers have saved anywhere from \$20,000 to \$200,000 per part, and removed weeks and months from the process. Additional benefits of 3D printed casting patterns include the ability to:

## PRODUCE PATTERNS WITH GREATER DESIGN COMPLEXITY

Without the limitations and restrictions of traditional wax pattern production processes, 3D printed casting patterns can deliver higher design complexity.

## PRODUCE PATTERNS SIGNIFICANTLY FASTER

Customers have cut weeks and months from the time taken to produce casting patterns and reduced time to casting by 90% or more.

## SAVE SIGNIFICANT COSTS OF PRODUCTION

Customers have saved hundreds of thousands of dollars with 3D printed casting patterns in direct comparisons.

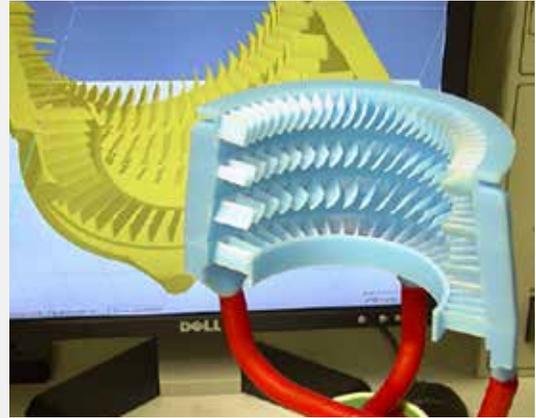
Rapid production of casting patterns also helps quickly identify design flaws to reduce the need for costly design changes and rework that can lead to massive time and cost overruns.

## INCREASE PRODUCT QUALITY AND FINISH

The perfect surface resolution of stereolithography (SLA) casting patterns delivers an unprecedented level of quality to the final casted parts, reducing lengthy machining and post-processing requirements.

	CONVENTIONAL PROCESS	TECH CAST PROCESS
Total time to finish casting	10-12 weeks	4 weeks
Labor cost (at \$60/hr)	Base	Base - \$81
Purchases	\$40,000	\$3,150

Customer benchmark shows that 3D printed investment casting can provide an impeller in roughly one-third of the time and at one-tenth of the cost compared to conventional processes.



## Turbine Technologies Improves Turbine Blade Product Iteration with 3D Printed Wax Patterns

### Challenge:

Expert R&D team needs to reduce costs yet increase quality of 3D printed blade casting patterns for critical product development.

### Solution:

3D printed wax patterns from ProJet MJP 3D printers

### Results:

- 90% cost savings on casting patterns, from \$20,000 to \$2,000
- Patterns produced overnight, compared to weeks waiting for traditionally-created patterns

# The 3D Systems End-to-End Approach to Investment Casting

3D Systems offers two key 3D printing technologies for creating investment casting patterns: stereolithography (SLA) and Multijet Printing (MJP). Yet while 3D printing technology is a major contributor to the drastic cost and time reductions possible with investment casting, there is more to the solution than a 3D printer alone. 3D Systems' end-to-end additive manufacturing solutions help to streamline this time- and labor-intensive task with the software, hardware, and printing materials required to transform the investment casting methodology into a 21st century process.

3D Systems On Demand offers manufacturing services, including expertise in investment casting. The On Demand team can produce high quality complex parts to bring the benefits of outsourcing to investment casting projects from prototyping to production using a range of processes.

## Aerospace Parts Supplier, Vaupell, Delivers Casted Parts Faster and More Cost-Effectively Than Ever Before with 3D Printed SLA Casting Patterns

### Challenge:

With the market becoming yet more competitive and cost-conscious, how can Vaupell work to compete successfully for its aerospace clients?

### Solution:

3D Systems ProX® 800 SLA 3D printer and Accura® CastPro Free materials

### Results:

- Cut delivery time for complex casting patterns from several months to a few days
- Cut costs of casting patterns from \$200,000-\$300,000 to \$6,000-\$15,000
- Enabled iterative process without high costs



# Stereolithography and the QuickCast® Build Methodology

SLA is the original 3D printing technology invented in 1983 by 3D Systems' Co-Founder and Chief Technology Officer, Chuck Hull, and is widely considered the gold standard for accuracy in 3D printing.

The QuickCast build style is an SLA print methodology developed by 3D Systems to answer a pressing need of the investment casting industry. The speed advantages and the high accuracy and quality of 3D Systems' SLA technology have made QuickCast one of the most popular and effective methods for 3D printed casting patterns in North America, as well as the preferred method for medical, aerospace and defense casting applications.

The QuickCast build style consists of a hollow SLA pattern with internal hexagonal supports that add strength to the pattern. This structure also facilitates the collapse of the pattern during thermal expansion, which helps to prevent the shell from cracking.

In addition to hexagonal support, 3D Systems offers a diamond-shaped support pattern, QuickCast Diamond. This unique structure offers up to 30% lighter patterns, single value shell thickness and improved, consistent pattern strength in any orientation, including better support of down facing geometries. The benefits for foundries and manufacturers include increased casting yields and reduced material costs as well as reduced skilled manual work. QuickCast Diamond allows for superior control and positioning of vents and drains on any surface, resulting in faster parts in hand. When used together with the low-viscosity Accura Fidelity 3D printing material, pattern draining is both fast and effective.

The internal design of a QuickCast pattern minimizes the amount of material used, creating an almost ash-free burnout that reduces manual steps and can deliver a higher quality cast. The QuickCast method improves upon other 3D printing-based methods for creating investment casting patterns, offering advantages such as lower moisture absorption, smooth surfaces, high dimensional stability, and the ability to produce large pattern sizes to bypass or limit the need for assemblies.

With QuickCast patterns, castings can be created at a fraction of the time and cost of traditional tooling to produce wax patterns. This allows designs to be evaluated in days instead of weeks or months. The use of QuickCast patterns can also provide the user with invaluable gating and shrinking information prior to hard tooling.

3D Systems offers a selection of high quality SLA printers, engineered to deliver true-to-CAD parts to meet a wide range of applications. These printers create exact plastic and composite material parts without the restrictions of CNC or injection molding. With the accuracy, surface quality, size and detail achievable with 3D Systems' SLA technology, producing low- to medium-run parts is not only faster, but per-unit part costs are lower.



# Stereolithography QuickCast® Materials

## ACCURA® FIDELITY™ MATERIAL

Designed for a variety of castable metals, Accura Fidelity is an antimony free material, with an ultra-low ash content of below 0.010%, offering low viscosity and a superior clean burnout. Combined with cutting-edge software, Accura Fidelity quickly creates large, lightweight, and easy to handle casting patterns. The low viscosity of the material makes it an excellent choice for fast and effective draining. Accura Fidelity is a total casting solution when used in combination with QuickCast Diamond and Accura Patch and Bond and is ideal for casting metals such as titanium alloy.

## ACCURA® CASTPRO™ MATERIAL

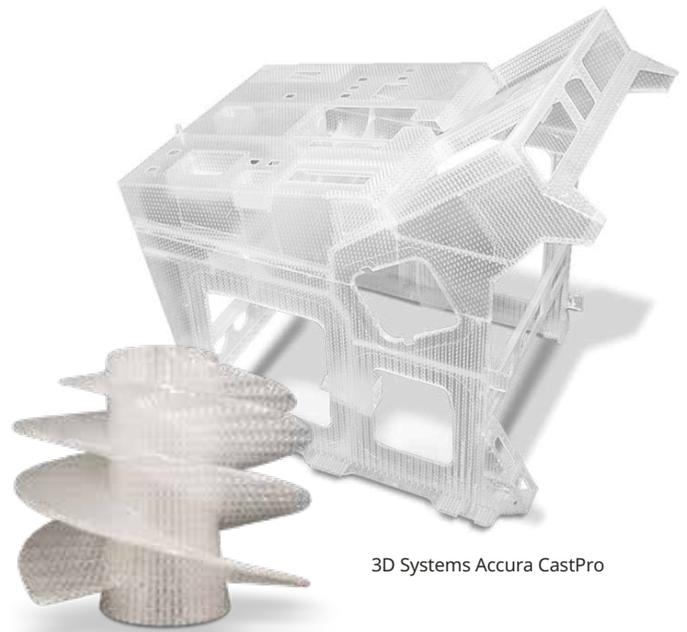
3D Systems Accura CastPro is an accurate, expendable pattern material ideal for QuickCast investment casting. It is good for both metal parts prototyping and low-to-medium production runs without tooling. It can be used to create titanium, aluminum, magnesium, and zinc castings as well as ferrous castings.

### Key Benefits:

- Higher quality master patterns for investment casting parts
- Less part finishing time with ease of post-curing
- Users can build accurate and tough parts that retain their dimensions and impact resistance over time without switching the material vat for different applications

## OTHER CASTING MATERIALS

3D Systems offers a selection of materials for the investment casting process, varying in durability, resolution, moisture resistance and purity, among other properties. Specialized materials for casting include clear plastic, wax-plastic hybrids, styrene-based for expendability, and more.



3D Systems Accura CastPro

3D Systems Accura Fidelity



Excellent humidity/moisture resistance



Transparent



Stable

## FINISHING AND JOINING FOR LARGE PARTS

To provide a complete workflow solution for QuickCast master patterns, 3D Systems offers Accura Patch and Bond designed for fast and easy filling of vent and drain holes. For large parts, Accura Patch and Bond can be used to join multiple parts together to create a single, large, seamless assembly.



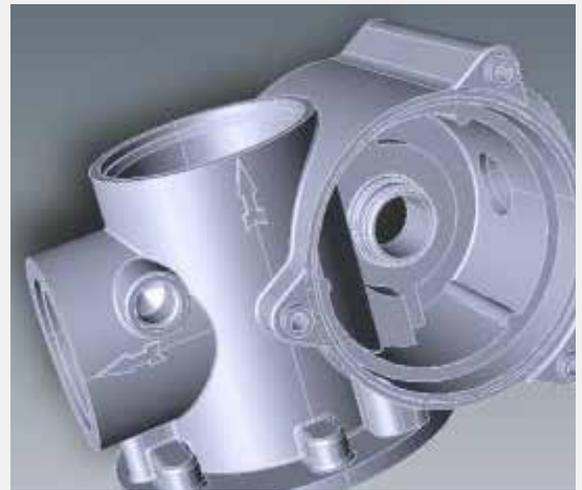
## Wax Multijet Printing for Investment Casting

Wax Multijet Printing (MJP) from 3D Systems uses an inkjet process to deposit RealWax™ materials. The material is deposited layer-by-layer, and offers high resolution builds. Depending on the model and material in use, layer thickness can be as thin as 16 microns (0.000591 inches). Advancements in materials science have improved the durability of wax parts printed in MJP, making the patterns more robust and reliable throughout the casting process.

In the case of investment casting, MJP wax materials deliver very fine detail for patterns quickly, with excellent outcomes for small parts in jewelry and dental applications as well as smaller industrial parts.

MJP Wax is ideal for a wide range of parts and patterns requiring fine feature detail. These systems are economical to own and operate, and use a separate meltable or dissolvable support material for quick post-processing. The process of removing support material is virtually hands-free; even the most delicate features and complex internal structures can be thoroughly cleaned without damage.

MJP wax printers are suitable for many direct investment casting applications where digital workflows already exist. Their ease of use and office compatibility make them a time-saving and cost-effective alternative to traditional lost wax casting processes. MJP Wax printers can create virtually any geometry for one-off or scalable volume throughput.



### Elster Aeroteh Delivers Casted Gas Regulation Assemblies in a Matter of Days

#### Challenge:

Romanian team needed to cut months from its gas regulation assembly casting process by producing casted parts locally.

#### Solution:

3D printed wax parts from the ProJet MJP 3D printers

#### Results:

- Casted parts produced in 12 days rather than months



# Castable Wax Materials

## VISIJET® M2 ICAST MATERIAL FOR FOUNDRY

A paraffin-based wax for the ProJet MJP 2500 IC printer; ideally suited for small- to medium-sized industrial component casting patterns.

### Key Benefits:

- Durable, high quality patterns
- Reliable performance and results throughout existing lost-wax casting process and equipment.



High resolution



High contrast color



100% wax

## 3D Systems On Demand for an Agile Manufacturing Workflow

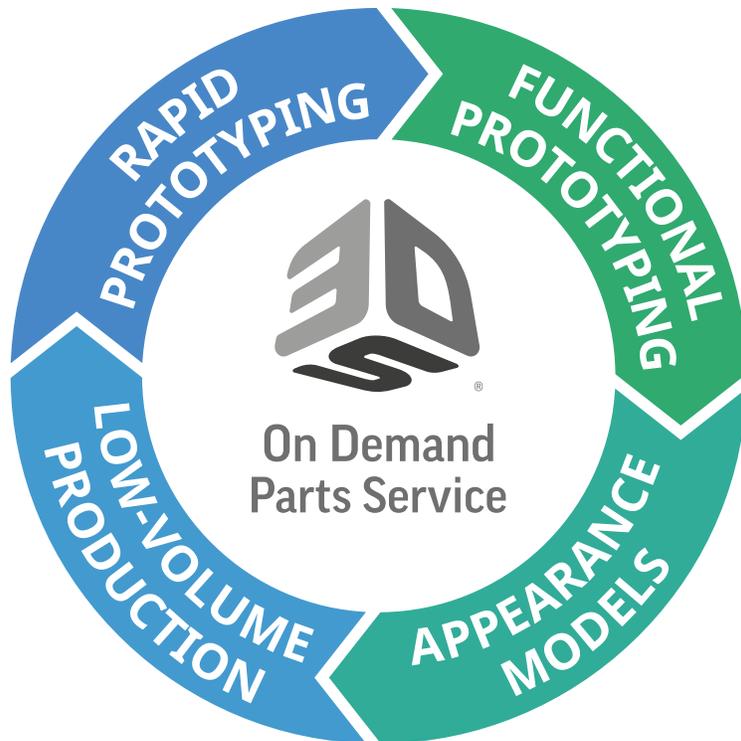
Accelerated response and iteration is essential to agile manufacturing. 3D Systems On Demand offers individuals and organizations an opportunity to test out new processes, materials, and technologies without having to make significant capital or infrastructure investments.

3D Systems On Demand allows companies the ability to pair their internal 3D printing services with the expanded network of machines and experts in facilities around the world. In addition to providing access to one of the largest collections of 3D printers in the market, we also provide a full complement of traditional manufacturing services. Our four pillars of manufacturing solutions include: rapid prototyping, advanced prototyping, appearance models, and low-volume production.

For those new to the concept of 3D printing for prototyping, or expanding its use into other areas, our experts often serve as outside advisers, helping select the right approach to

particular design and engineering challenges. With a global network of facilities, we are able to offer a broad range of production processes and technologies for both 3D printing and traditional manufacturing. Access to these advanced tools of product development and manufacturing help speed the implementation of prototyping across the entire manufacturing lifecycle—helping accelerate innovation and move through iterative design cycles faster.

3D Systems On Demand delivers the ability to provide instant online quotes and production resources strategically located in key markets to ensure ease of access, and a personal and consultative approach to problem solving. This approach allows ideas for new products or manufacturing processes whether you are starting with a simple sketch of an idea or already have your 3D CAD file(s). Our facilities are certified to meet ISO's quality management system standards and comply with both ITAR and AS9100C specifications.

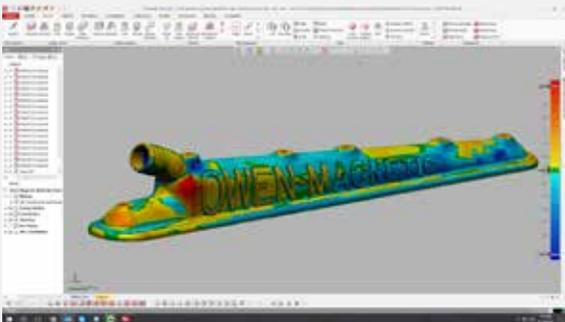


## The Final Result

Using 3D Systems' end-to-end manufacturing solutions for investment casting can revolutionize manufacturing processes. 3D printing enables casting patterns to be created much faster than with traditional methods, at significantly reduced costs. The ability to print, test and adapt casting patterns quickly also makes 3D printing the only repeatable and cost-effective option for casting patterns that may need to undergo change. The materials available are precise, and the printing process is true-to-CAD. Furthermore, 3D printing allows companies to create digital inventories of casting pattern models to print or modify on demand. 3D printing technology delivers logistical benefits with high-strength, lightweight molds that are easier to handle and transport than their conventional tooling counterparts.

### Next Steps to Adding 3D Printed Casting Patterns to Your Workflow

- [Read more Investment casting stories](#)
- [Contact a 3D Systems specialist](#)
- [Learn more about On Demand Manufacturing](#)



### Rapid Creation of Casted Engine Parts for Owen Magnetic

#### Challenge:

Quickly recreate old parts to deliver foundry castings.

#### Solution:

Scan the old parts and recreate the data in Geomagic Design X software to print the SLA pattern for foundry casting. 3D printed casting patterns delivered by 3D Systems On Demand.

#### Results:

- Accurate recreation of part
- Quick SLA pattern turnaround
- Completed part in 4 weeks

# Investment Casting Printer Comparison Charts

	ProX® 800	ProX® 950	Projet® 6000	Projet® 7000
<b>Max Build Envelope Capacity (WxDxL)</b>	650 x 750 x 550 mm (25.6 x 29.5 x 21.65 in)	1500 x 750 x 550 mm (59 x 30 x 22 in)	250 x 250 x 250 mm (10 x 10 x 10 in)	380 x 380 x 250 mm (15 x 15 x 10 in)
<b>Casting Materials</b>	Accura® CastPro™ Accura® CastPro™ Free Accura® 60 Accura® ClearVue Free	Accura® CastPro™ Accura® CastPro™ Free Accura® 60 Accura® ClearVue Free	Visijet® SL Clear	Visijet® SL Clear
<b>3D Printing Process</b>	Stereolithography (SLA)	Stereolithography (SLA)	Stereolithography (SLA)	Stereolithography (SLA)
<b>Accuracy</b>	—————0.001-0.002 in per in (0.025-0.05 mm per 25.4 mm) of part dimension —————			
<b>Max resolution</b>	4000 DPI*	4000 DPI*	4000 DPI*	4000 DPI*
<b>Features</b>	<ul style="list-style-type: none"> <li>• Ideal for companies requiring high throughput or large parts in a single piece with highest accuracy and detail</li> <li>• Supports QuickCast build style patterns with lower moisture absorption, smooth surfaces, high dimensional stability and virtually an ash-free burnout</li> <li>• Offers antimony-free casting materials for clean burnouts necessary for aerospace applications</li> </ul>		<ul style="list-style-type: none"> <li>• Ideal for organizations who want all the benefits of SLA in a smaller footprint</li> <li>• Supports QuickCast build style patterns with lower moisture absorption, smooth surfaces, high dimensional stability and virtually an ash-free burnout</li> <li>• Versatile, high clarity material and also USP Class VI capable</li> </ul>	

	Projet® MJP 2500IC
<b>Max Build Envelope Capacity (WxDxL)</b>	295 x 211 x 142 mm (11.6 x 8.3 x 5.6 in)
<b>Casting Materials</b>	Visijet® M2 ICast (100% wax)
<b>3D Printing Process</b>	Multijet Printing (MJP)
<b>Accuracy</b>	±0.004 in per in (±0.1016 mm per 25.4 mm) of part dimension
<b>Max resolution</b>	600 x 600 x 600 DPI; 42 µm layers
<b>Features</b>	<ul style="list-style-type: none"> <li>• Ideal for small businesses, job shops and labs requiring precision parts in 100% real wax materials</li> <li>• Delivers very fine detailed patterns quickly, with excellent outcomes for very small parts in jewelry and dental applications as well as smaller industrial parts</li> </ul>

\* Equivalent DPI based on laser spot location resolution of 0.00635 mm in 3D Systems testing

\*\* Enhanced LED DLP technology provides an effective resolution of 585 DPI.

# What's Next? Interested in learning more about additive manufacturing solutions?

Talk to an expert about which materials  
and printers would work for you

Get in Touch

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