2017 DoD Maintenance Innovation Challenge

Additive Manufacturing for Masking 76 PMXG Thermal Spray

bo5_am_for_masking.pdf

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3D Printed Masking for TS

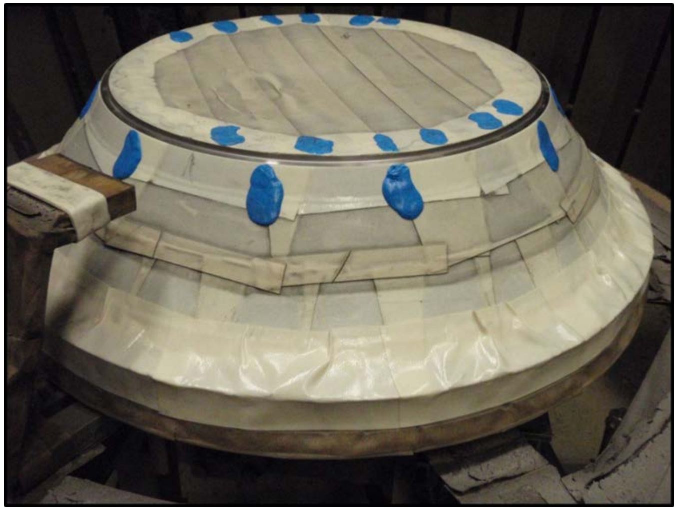
Thermal Spray Basics

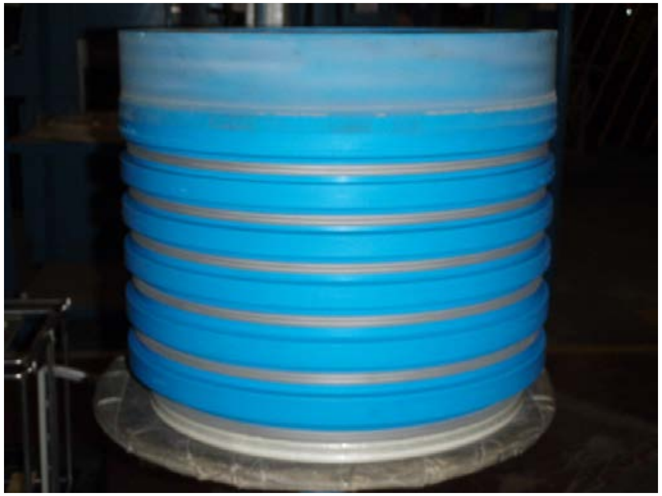
- Used to apply a variety of coatings for different applications
  - Dimensional restoration
  - Wear/ corrosion resistance
  - Abradables
  - Thermal barrier coatings
- High temperatures and velocities
  - For plasma spray:
    - Particle temperatures: 3500°F – 5500°F
    - Particle velocity: 100 - 200 m/s (225 - 450 MPH)
    - Part temperatures: 200 – 500°F

3D Printed Masking for TS

Why do we need a new way to mask?

- Currently there are 2 common masking methods:
  - Glass fiber reinforced tape
    - Can be used on just about any part
    - Time consuming and expensive
  - Silicone rubber
    - Repeatable, cheap, and fast
    - Often difficult to acquire for military engines and can have long lead times





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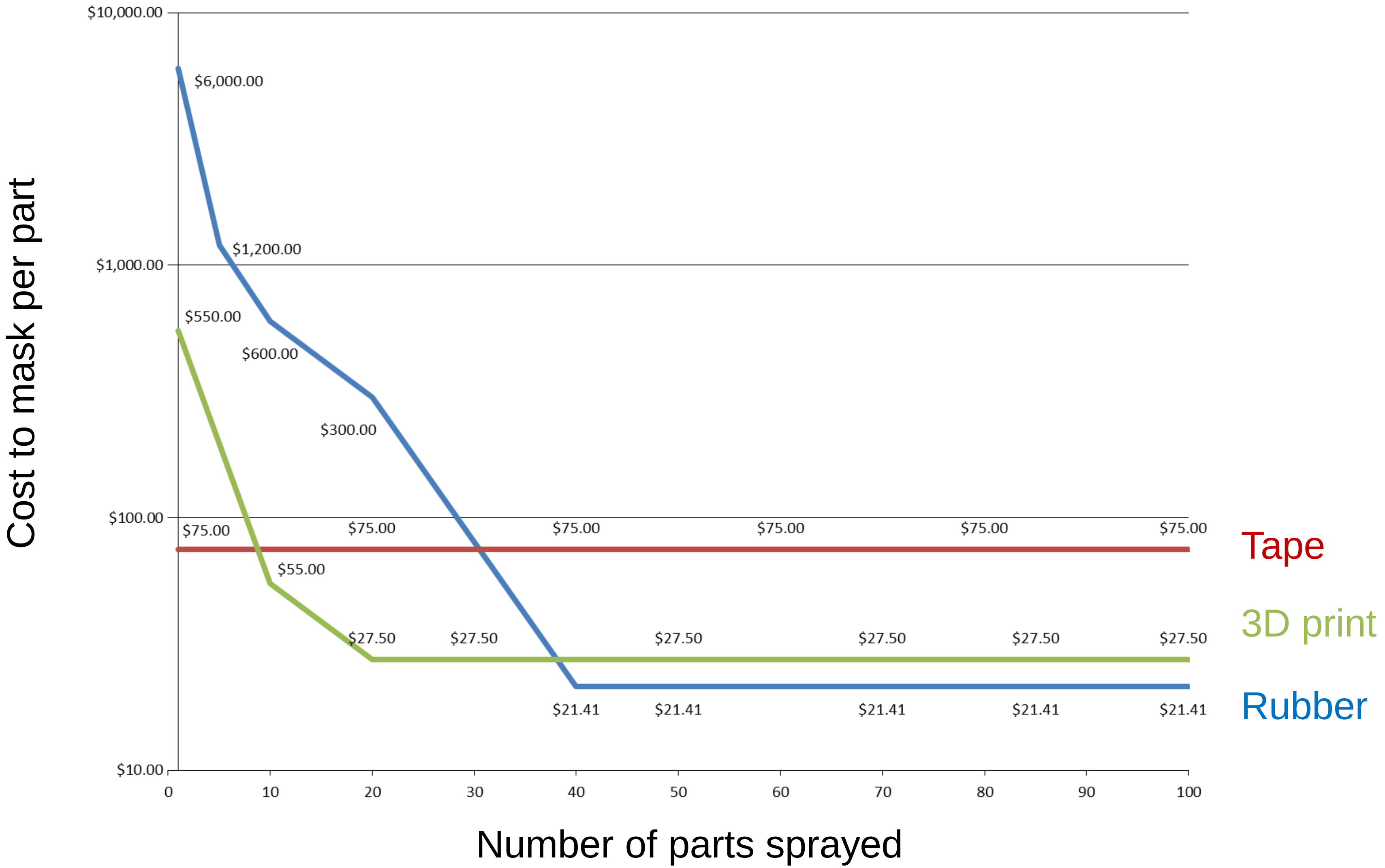
Cost Comparison



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Coatings Tested (Partnership with AIM-MRO)

Process	Coatings tested	Solutions
Plasma (metallics)	Ni-Al, Ni-Cr-Al, Inconel 718, Cu-Al	Polycarbonate (PC) Ultem 1010
Plasma (ceramics)	TBC, Al-O, Tungsten carbide	Ultem 1010
Wire arc	Ni-Al	PC, Ultem 1010
Shot peen	Cut wire, Ceramic bead, Glass bead	PC, Ultem 9085, ABS
HVOF	Ni-Al	No solution to date
Cold spray	Al	No solution to date
Grit blast	Al-O	ABS, PC, Ultem 1010, Ultem 9085

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Case study: On demand tooling benefits

- Supply behind on procurement of blades for specific engine line that was leading to a line stop
- Approached by the program office on timeline to stand-up repair of the blades by PMXG
- Previously this would have been a process that took months
  - Approval to send blades to masking vendor
  - Design of silicone mask
  - Cast mold
  - Pour mold to create silicone mask
  - Ship masks to PMXG

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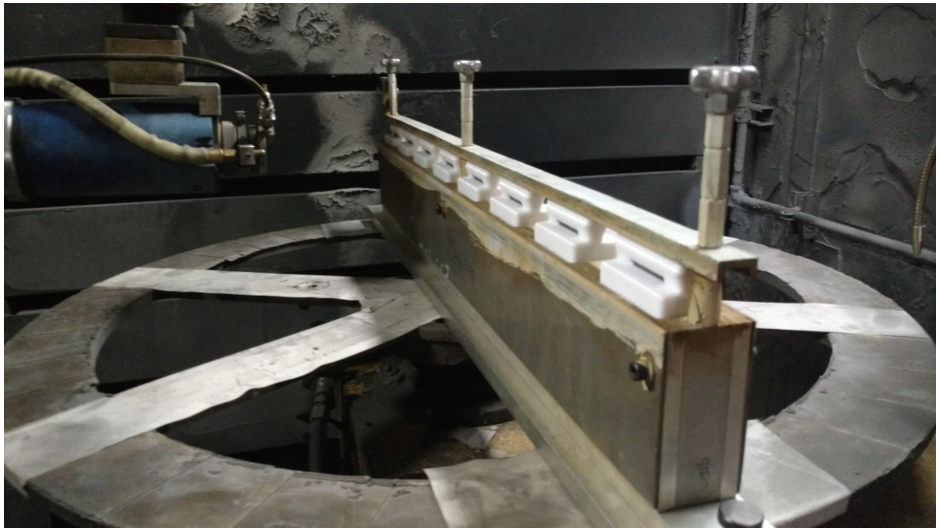
Case study: On demand tooling benefits

- Using 3D printed PC masks, repair was qualified and ready in one week
  - Tool designer created 3D model, masks printed overnight
  - Masking tested the next day, 3D model modified and new masks printed overnight
  - Version 2 of the mask sprayed the following day resulting in successful prototype parts



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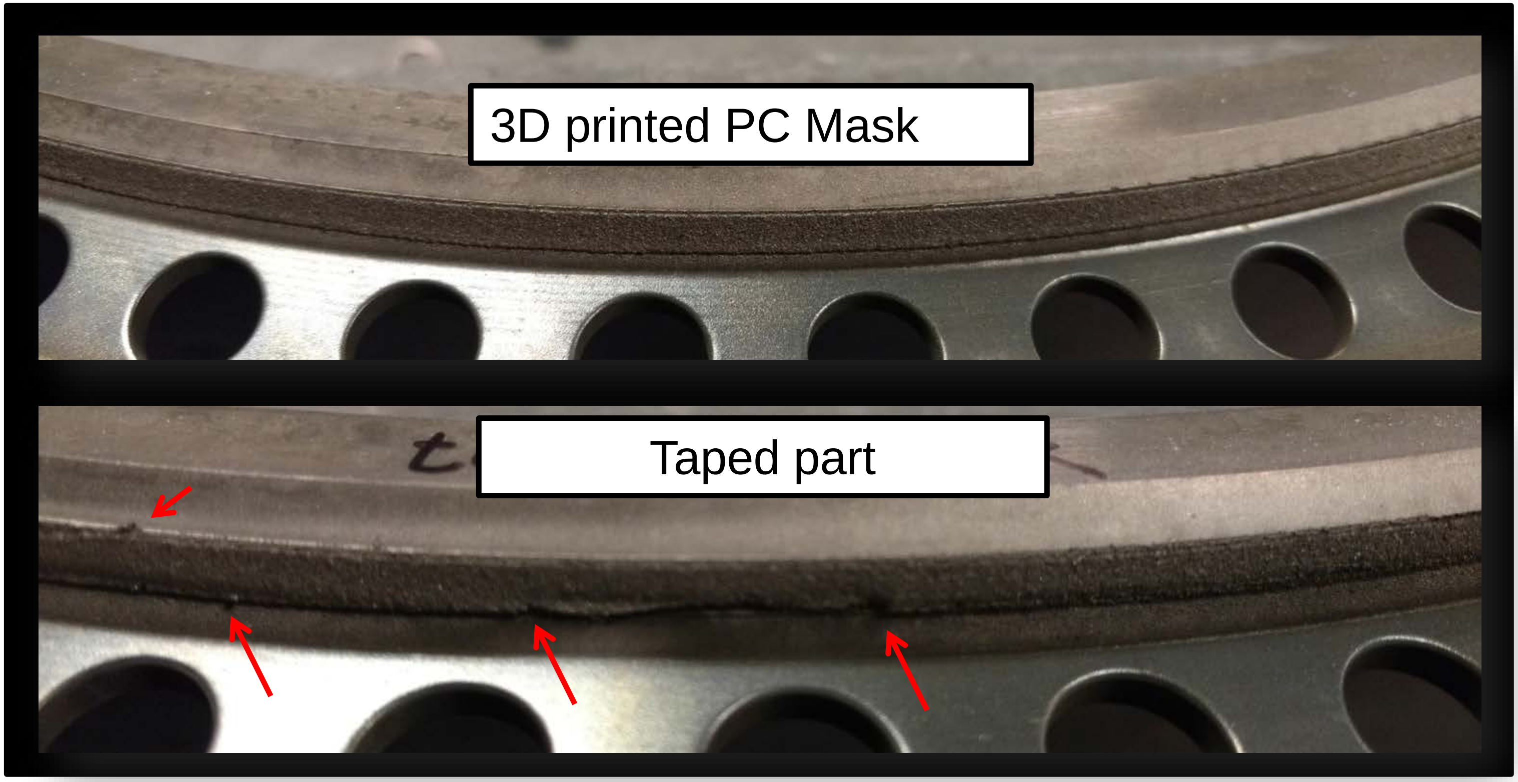
Improved edge definition

- 3D printed mask results in a more consistent masking line and a cleaner line that may reduce recycles in post machining



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Case study: Cost savings

- Cost to tape each part (3 processes): $592.14
- 3D printed mask: $678.24
- Estimated yearly repair requirement: 58 parts
- Cost avoidance per part (3 processes): $524.05
- Yearly cost avoidance (including labor costs): $30,394.90
- Yearly labor savings: 304.5 hours

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Conclusions and future work

- Benefits
  - Fully organic process (short lead times)
  - Improved edge retention and repeatability
  - Cheaper than taping for some applications
- Drawbacks
  - For large numbers of parts, not as cost efficient as silicone rubber masking
    - Due to build up of plasma on 3D printed mask that cannot be removed
- Future Work
  - Looking at new ways to strip 3D printed masks, or coat masks before spray to prevent buildup

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Questions?

Thank you to my collaborators:

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