# Additive manufacturing and the military: Applications and implications

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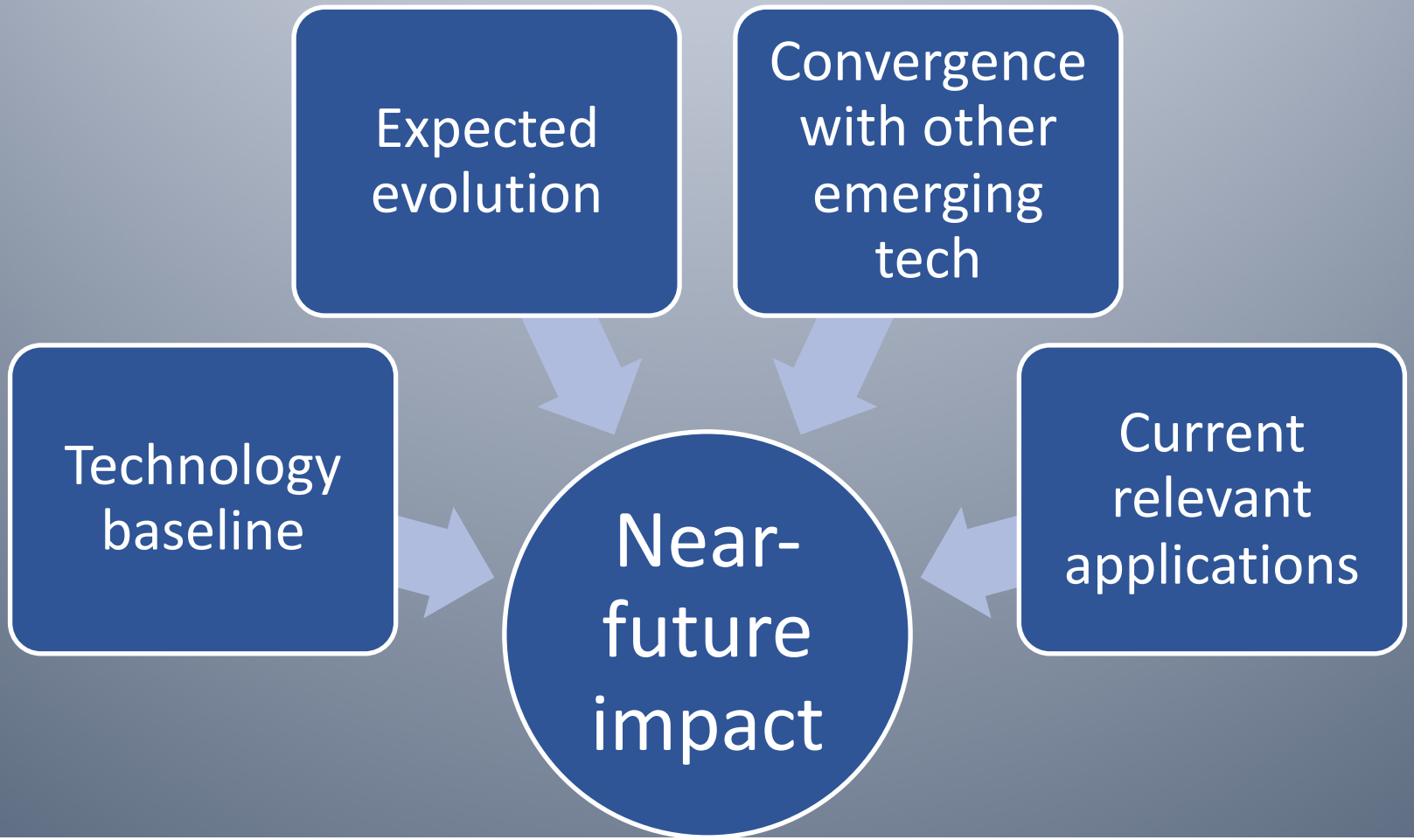
# Contents

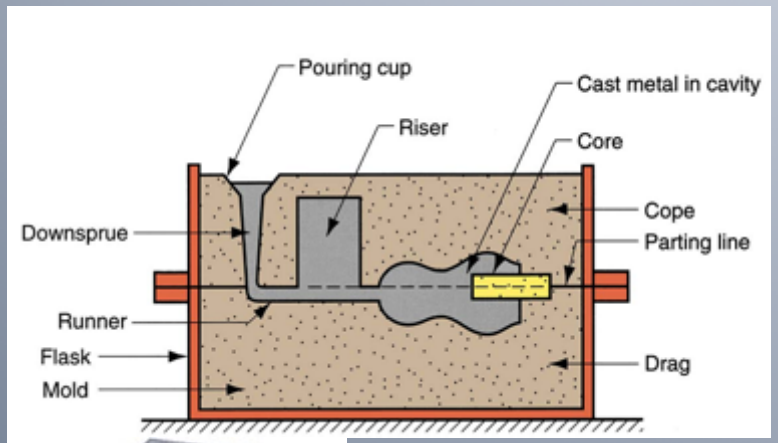
- The author's perspective
- How to structure answering this question
- An introduction to manufacturing and what is new about additive manufacturing
- What is being printed
- Military applications
- Implications for military strategy

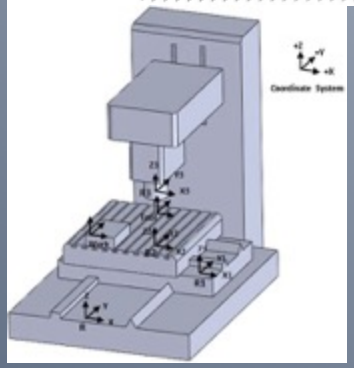
# Structure to evaluate impact of emerging tech



# Manufacturing – a primer

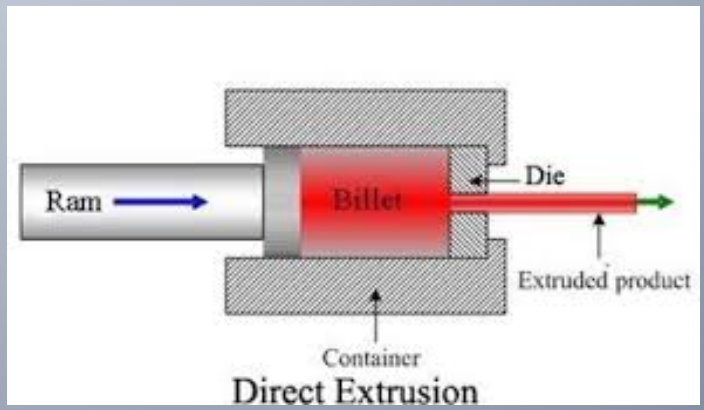
Sand casting



3-axis milling

Extrusion




5-12 axis machines



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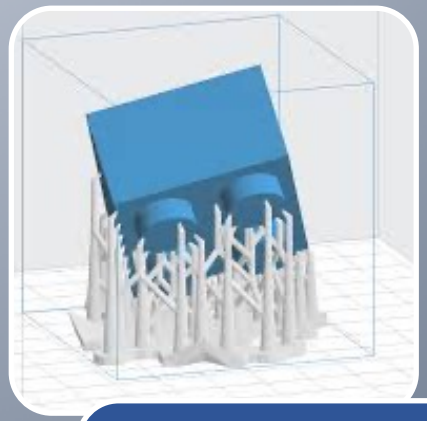
# 3D Printing – a primer

## Design

- Computer-aided design
- Instruct printer how to print

## Print

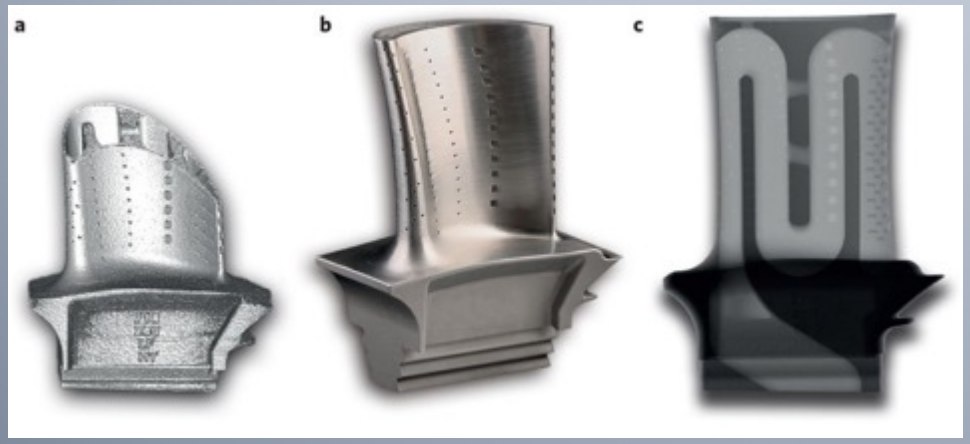
- Choose process
- Choose material



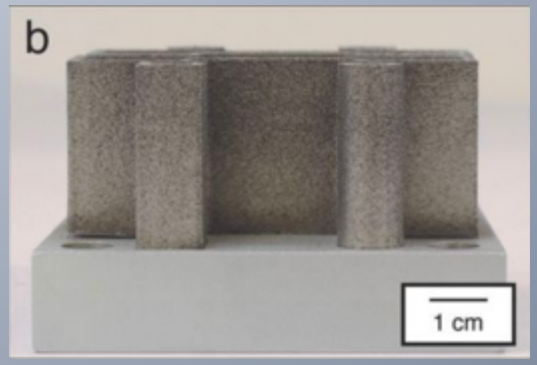
## Postprocess

- Cut supports
- Quality assurance

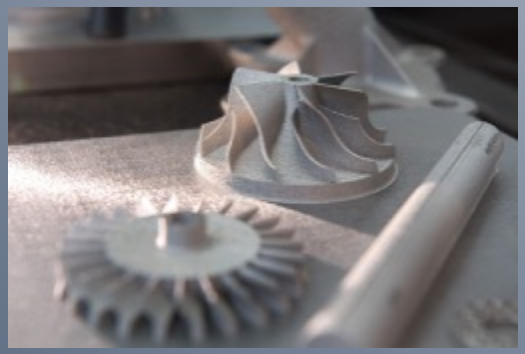
# Available materials




Inconel turbine blades




Aluminium 7075



AF96 steel impeller printed by the US Army

PEEK – high strength plastic

Ti-6Al-4V

# 3D printing vs computer aided manufacturing

**3D printing**

- Rapid prototyping
- Digital designs
- Amorphous materials and wires
- Small to medium -sized factories
- Customisation from any process
- Slow
- Replication problems

**Other Computer-aided manufacturing**

- Rapid prototyping
- Digital designs
- Large solid materials, (amorphous casting)
- Medium to large –sized factories
- Customisation via multi-axis machines
- Fast
- Reliable





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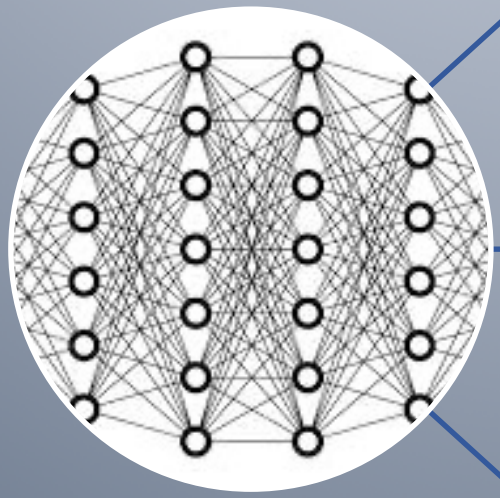
# AM plus AI



Rapid Design

- 3rd Offset strategy
- New systems to solve problems introduced during protracted conflict

Reliable Design

- Identify and correct failures

Generative Design

- Design by algorithm
- Potential game changer
- Applicable to all digital manufacturing

# AM and the IoT


Hardware Blockchains

- Permissive manufacturing
- Validate designs against sabotage

Embedded sensors in parts

- Predictive maintenance
- Conformal sensors

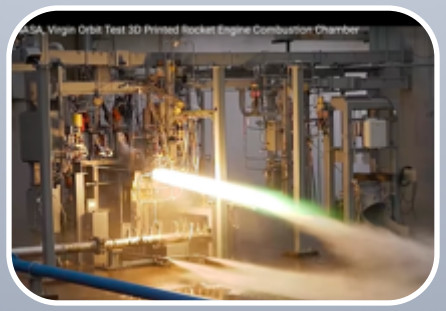
# AM and 3D scanning

- Older systems can be more easily maintained
- When supply chains are no longer available a 3D scanner can be used to reverse engineer a part
- Siemens replaced an impeller at the Krško nuclear power plant in Slovenia

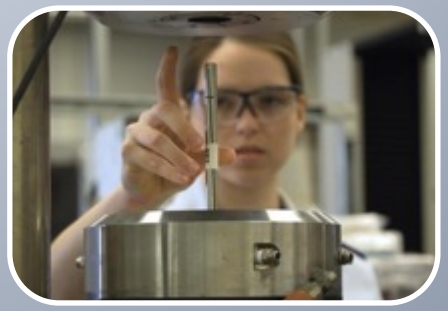
Impeller reverse engineered by Siemens for the Krško nuclear power plant in Slovenia. Original (l), 3D-printed prototype (c), 3D-printed final part (r).

# Current military applications

Aerospace parts




Missile parts



Conventional munitions parts

Rapid Equipping Force

Naval trials

# AM and international security

- A state that is able to maintain an asymmetric advantage in design agility and flexibility will better placed to counter any unanticipated strategic or tactical disadvantage
- States that are overly-reliant on small numbers of expensive systems could be overwhelmed without a commensurate rapid manufacturing capability
- Limiting the spread of additive manufacturing is difficult
- States that desire autarky will seek to integrate AM into their industrial capabilities

# Addressing the challenge

- Strengthening cybersecurity
  - The most valuable intellectual property for AM is not the geometry of the part but the instructions to the machine for how to build it.
- Export controls
  - AM is already global
  - International service providers already exist
- Awareness
- Industry self-regulation
  - Reluctance to control the technology is rooted in a desire to maintain any commercial advantage which will also lessen the effectiveness of self-regulation by industry

# Takeaways

- Based on our current understanding, AM will not have a transformative effect on military strategy
- It will likely have significant impact in the specific areas of design, mobile repairs and integrated sensors

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# Questions?

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