



Dedicated to innovation in aerospace

Additive Manufacturing: The Great Disruptor

Some remarks from NLR

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ap&m summit, London, 29 May 2018



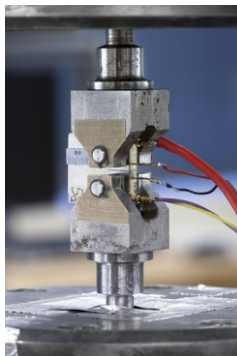
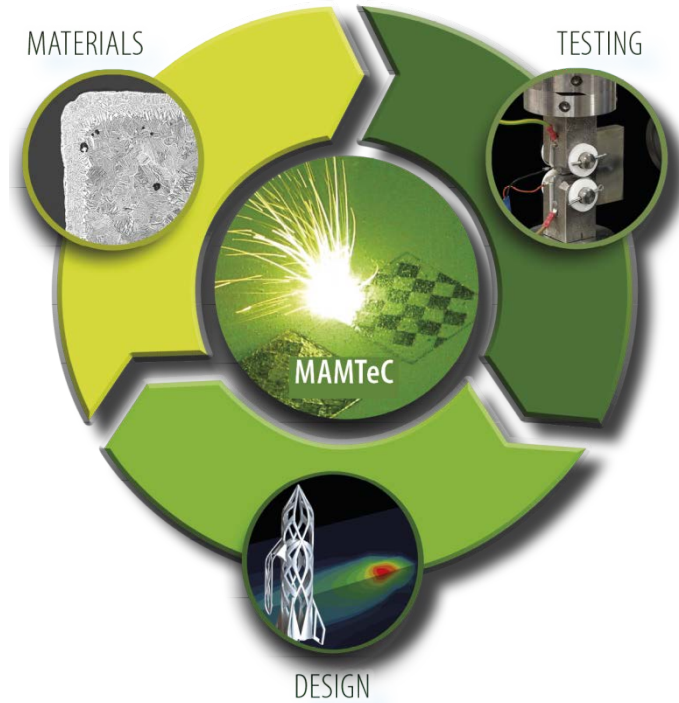
am&p raised questions about MRO additive manufacturing

- What is the potential impact of 3D-printing on the MRO landscape?
- Does the technology offer potential for a 'truly digital' supply chain?
- What challenges will MROs face in certifying components?
- Is there an impending market surge for additive metal manufactured replacement parts?
- How will the technology be integrated throughout the aftermarket?
- Will the introduction of 3D-printed processes lower unit prices, or is its impact likely to be felt more in inventory management strategies?

NLR's Metals Additive Manufacturing Technology Centre

The Metal AM Technology Centre in NL

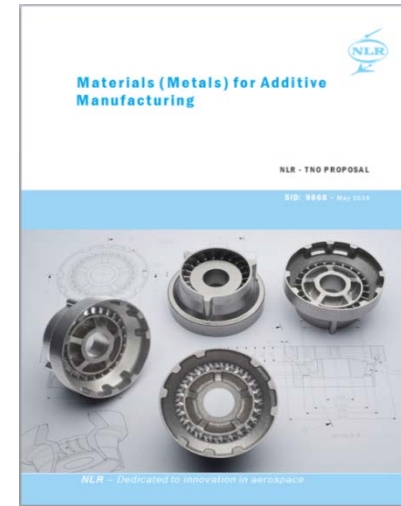
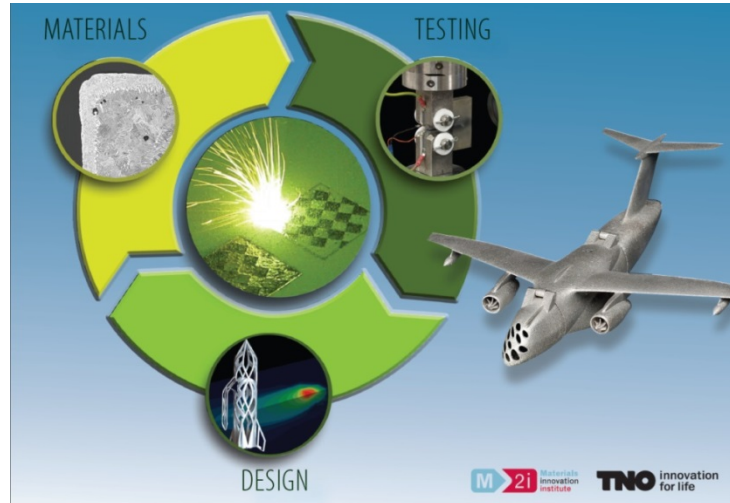
- Unique combination of knowledge, experience and facilities
- Qualification/Certification track record
- Focus on High tech - High spec applications
 - Materials: Ti6Al4V, Inc718, Aluminium, Magnesium



<http://www.nlr.org/capabilities/additive-manufacturing>

Metals for Additive Manufacturing track record

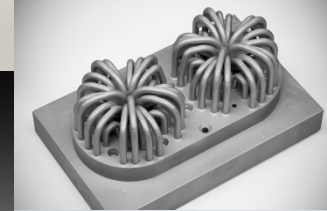
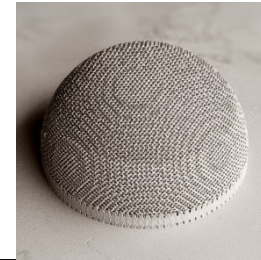
- Many programmes on Metal-AM for high tech applications
- E.g. Public-Private Partnership with international participants
- One of the objectives: Material qualification and process certification methodologies for AM





Examples of MAMTeC projects

- Research for Dutch Defence, (inter)national industries
- Parts for wind tunnel models
- Space applications
- Prototyping for various applications
- Process development new materials
- Process development Multimaterial AM





Disruptive Innovation

Disruptive innovation is:

- the introduction of a product or service into an established industry
 - that performs better and,
 - generally, at a lower cost than existing offerings,
 - thereby displacing the market leaders in that particular market space
 - and transforming the industry
-
- Source:
 - <https://whatis.techtarget.com/definition/disruptive-technology>



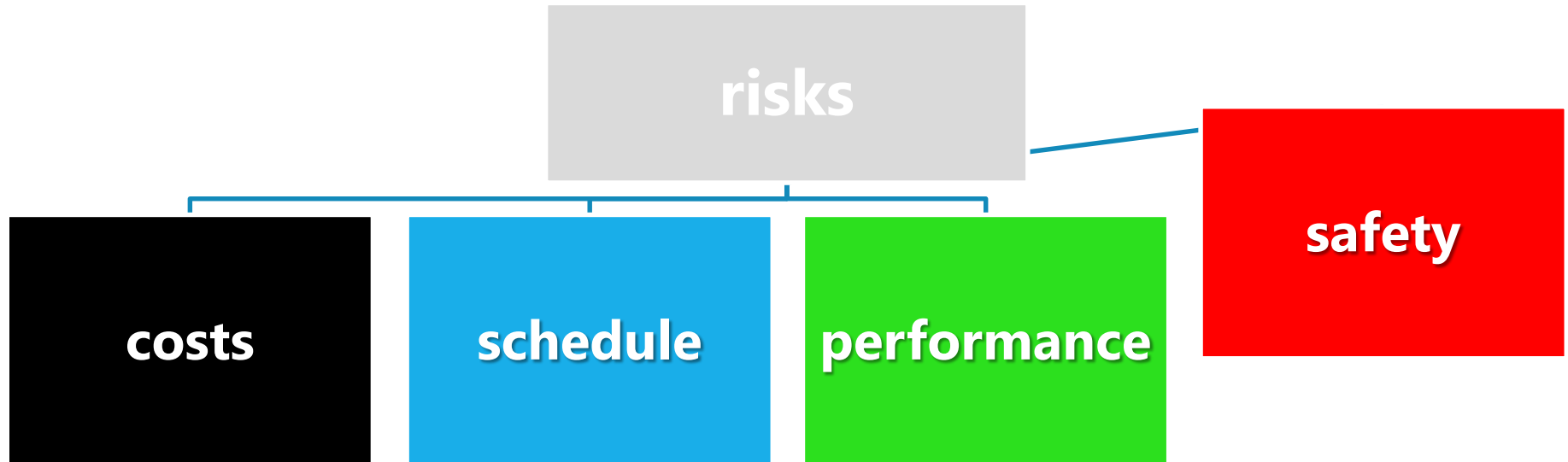
Disruptive technology

Characteristics

- New
- Not mature
- Limited known about performance
- Initially underperforms compared to existing technologies

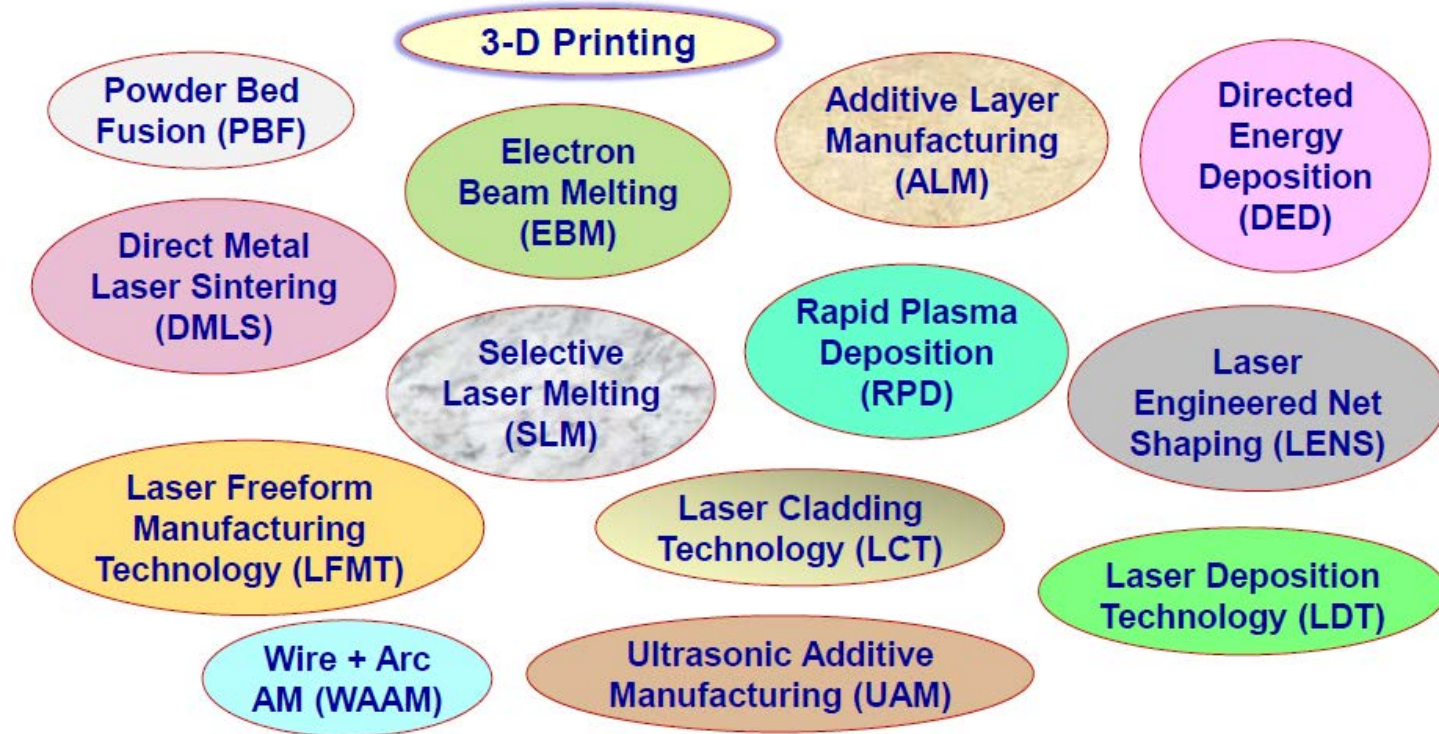
Poorly defined Risks: not acceptable in aerospace

Main risk categories aerospace systems/parts



AM is Not a Single Process...

...a *partial* list of metal AM technologies



- Different physics → different Q&C considerations
- Lack of common terminology (e.g. *L-PBF* / *SLM* / *DMLM* / *DMLS*)



“Traditional Fabrication” vs “Additive Manufacturing”

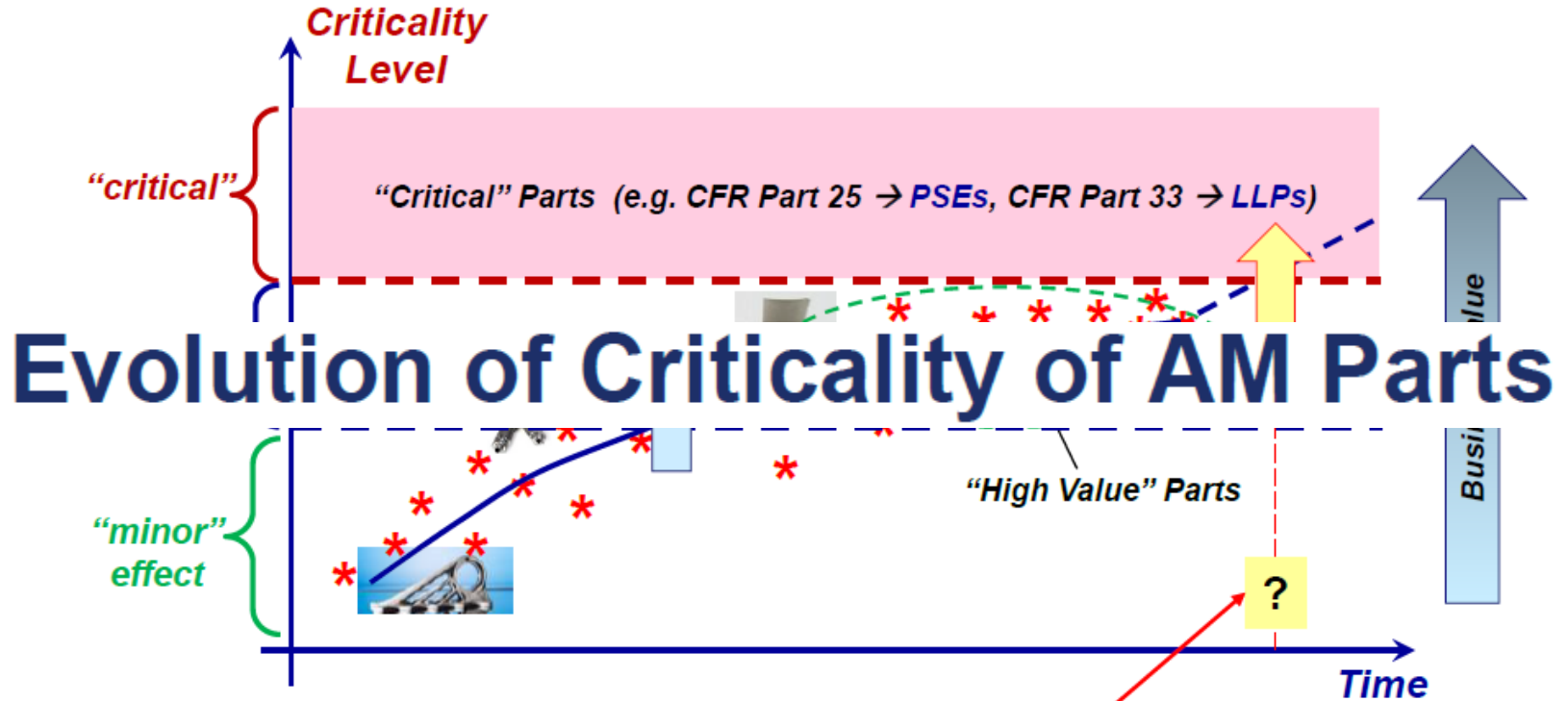
<u>Common</u> Industry Understanding or Acceptance of:	AI 2014 Cast (common airframe alloy)	AI 2014 Cast (common airframe alloy)	AM alloy (airframe or engine alloy)
Material and process specs	Yes	Yes	No / WIP
Design allowables	Yes	Yes	No / WIP
Capable NDI methods	Yes	Yes	No / WIP
Characterization of material defect / anomalies types	Yes	Yes	No / WIP
Key manufacturing process control parameters and acceptable ranges	Yes	Yes	No / WIP
Effect of process parameters on microstructure and mechanical properties	Yes	Yes	No / WIP
Qualification / certification criteria	Yes	Yes	No / WIP

Source: FFA, DER Conference March 2015

WIP = Work in Progress

Note: Large OEMs have more advanced understanding of AM technology than indicated in the table

Evolution of criticality of AM parts





Asian aircraft OEM/MRO party (spoken with April 2018)

3D-printing will play an important role in the future for MRO; why?

1. Obsolete parts: aircraft and or systems are out of production, suppliers stopped manufacturing, tooling no longer available
2. OEM owns designs
3. Particularly relevant for military spare part supplies (low volumes, short delivery times/availability, national certification authority)
4. View of airline customers will be different; discussions not yet started

AM repairs at gas turbine parts repair house

- CH-OEM repair development
- OEM approval
- Proprietary repair in manual
- Precondition: repair house needs sympathising OEM



courtesy of Chromalloy



AM repairs on gas turbine parts at maintenance shop airliner (1)

- Airliner/Maintenance shop-OEM repair development
- OEM approval
- Proprietary repair in manual
- Precondition: Airline maintenance needs agreement/licence from OEM

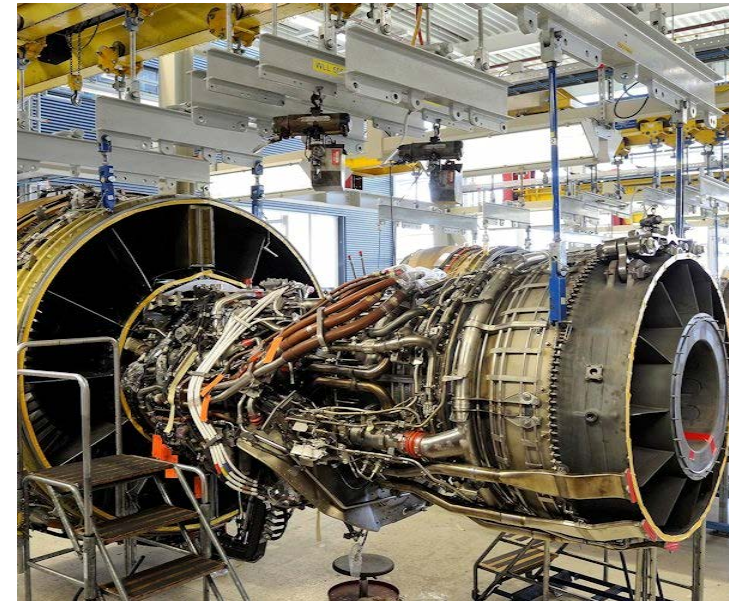


courtesy of KLM



Example 2: AM repairs on gas turbine parts at maintenance shop airliner (2)

- AM DED repairs for static and rotating knife edge seals (powder/laser)
- CO2 laser replacement by YAG lasers gave tremendous material quality improvement
- Recent repair developments for gas turbine casings, exhaust nozzles and retainers
- Repair limits significantly enlarged by AM DED over traditional repair methods
- HAZ quality and porosity well tested and inspected
- OEM qualified repairs



courtesy of KLM



Additive Manufacturer: The Great Disruptor?

The answer is probably in:

- For instance, the Internet is sustaining to catalog retailers and discount brokers, but it is disruptive to department stores and full-service brokers



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Fully engaged

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