Additive Manufacturing, regulatory challenges and possible solutions

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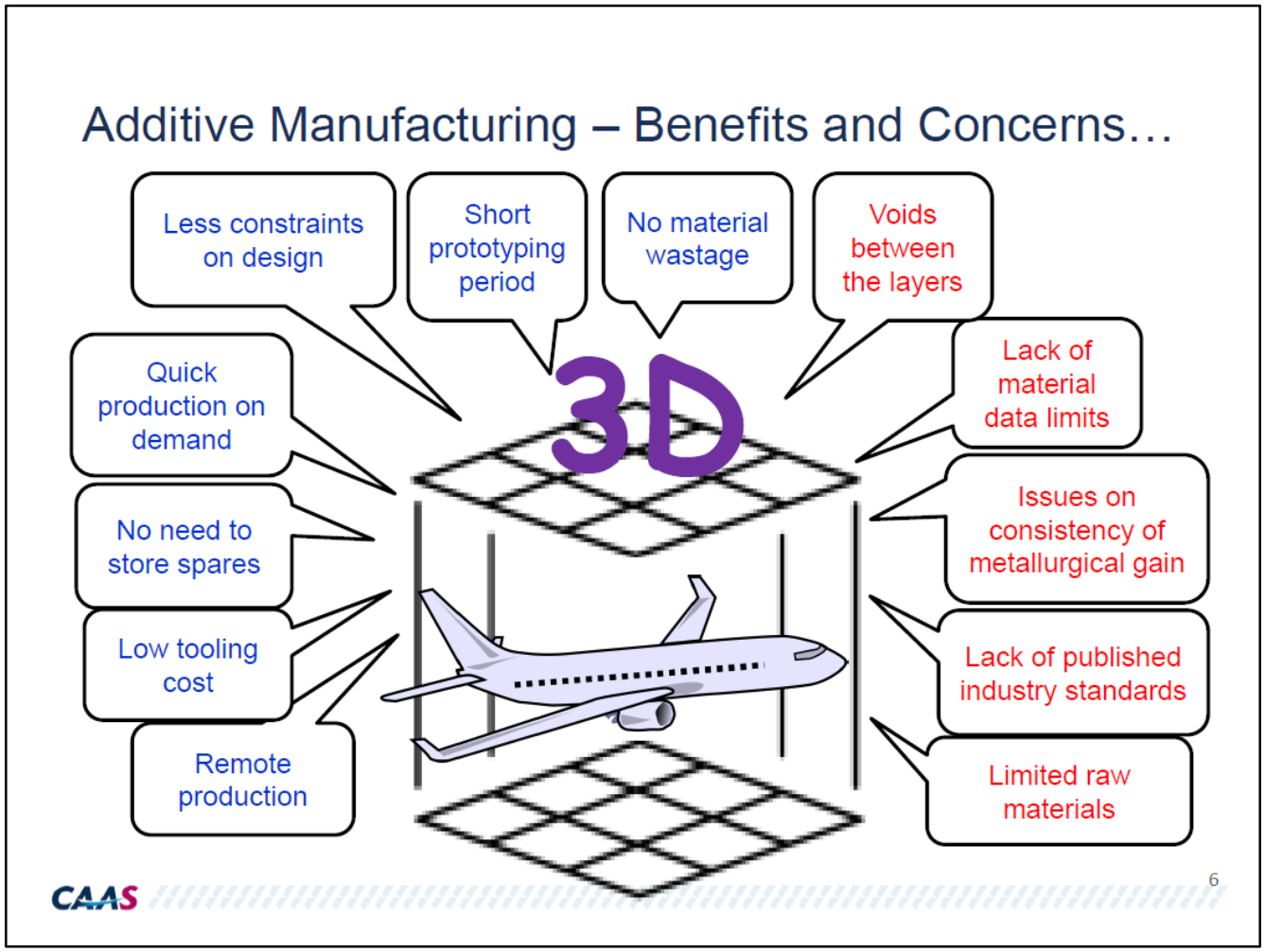
CAAS
Civil Aviation Authority of Singapore

Slide on Additive Manufacturing presented at 2016 SASS



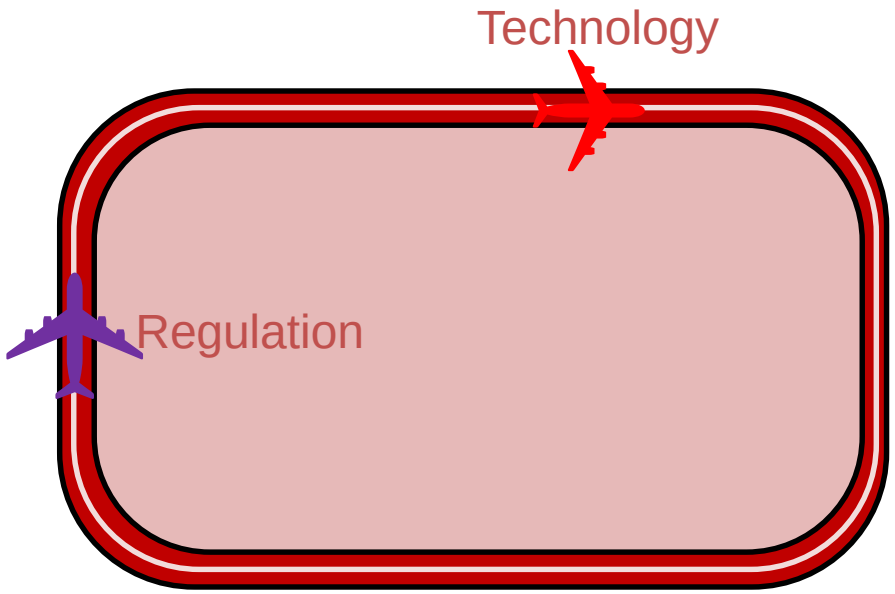
Agenda

- Subtractive vs Additive Manufacturing
- Regulatory Challenges
- Possible Solutions
- Summary

Regulation meets Technology…

Regulations is hindering the growth and implementation of technology?

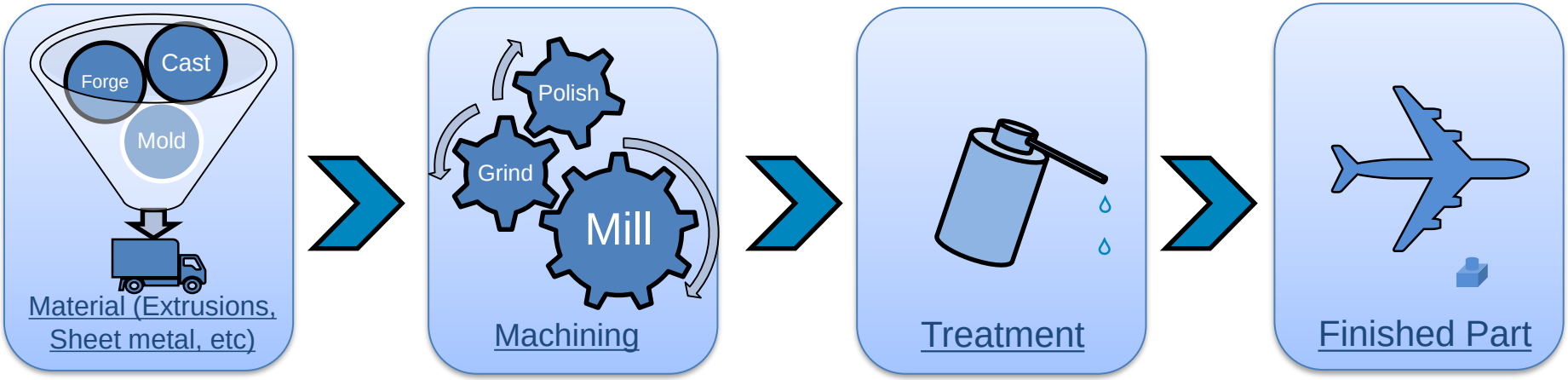
or



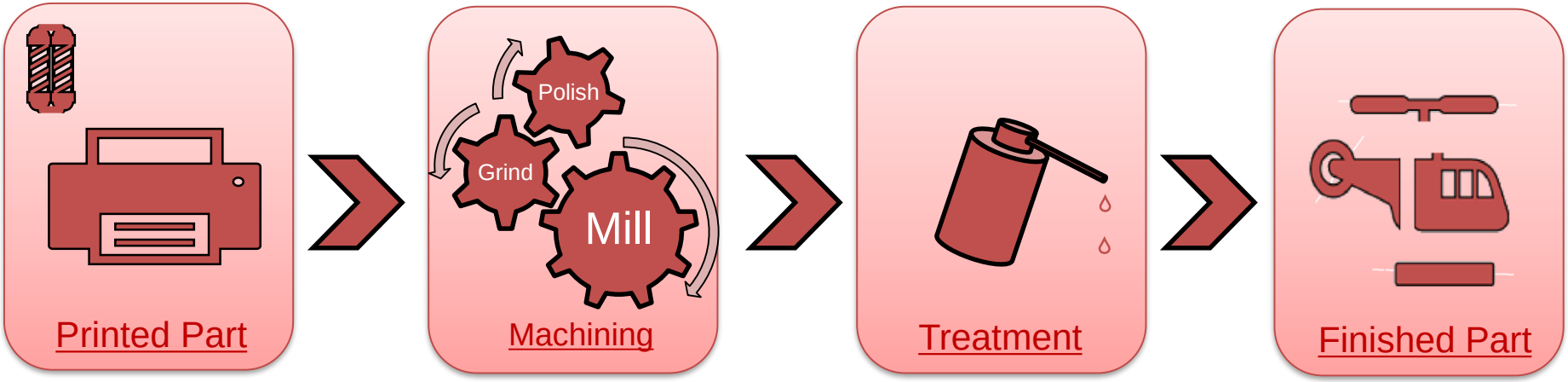
Regulations is following the after burner of technology?

Subtractive Vs Additive Manufacturing

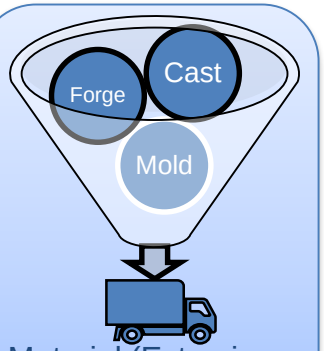
Subtractive Manufacturing



Additive Manufacturing

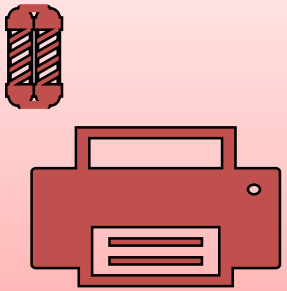


Additive Manufacturing Technologies



Material (Extrusions, Sheet metal, etc)

Compared against

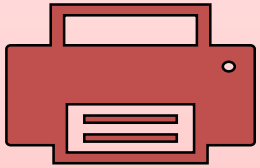


Printed Part

Additive Manufacturing LAN Printing Network

Material Extrusion

Selective Laser Sintering (SLS)



Direct Metal Laser Sintering

Material and Binder Jetting

Stereo Lithography (SLA)

Bio Printing

Aerosol Jet Systems

Electron Bean Melting (EBM)

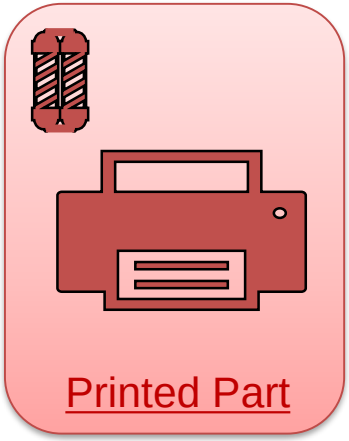
Digital Light Processing (DLP)

Laser Aided Additive Manufacturing (LAAM)

Ceramic Printing

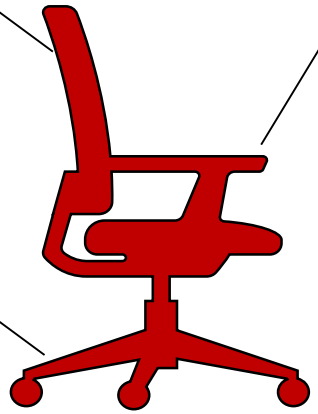
Many more…

Additive Manufactured Parts



Semi load bearing
- Might be required to experience load transfer to load bearing members

Load bearing
- Required to dissipate loads



Non-load bearing
- Not anticipated to experience any load.

Regulatory Challenges

1st Initial Certification

2nd Production

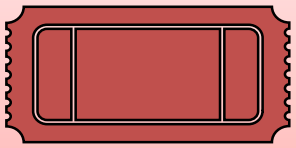
3rd Maintenance

Regulatory Challenges – Initial Certification

1st Initial Certification

Certification Requirements

- 14 CFR / CS 2x.307 – Proof of Structure – Structural analysis may be used only if **experience** has shown that the method is reliable.
- 14 CFR / CS 2x.603 – Materials – The suitability and durability of materials used for parts, must be established on the basis of **experience** or **test**;
- 14 CFR / CS 2x.605 – Fabrication Methods – Each fabrication methods must be substantiated by a **test programme**
- 14 CFR / CS 2x.613 – Material strength properties and material design values – Material strength properties must be based on enough **tests** of material meeting **approved specifications** to establish **design values** on a statistical basis.



Test Coupon

- Size?
- Orientation?
- Cutout of a fabricated part or fabricated coupon for testing?
- Machine variance?

Test Method / Results

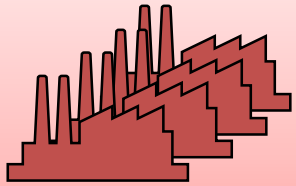
- Based on existing test methods or Statistical data?
- Orientation impact on test results?
- Accredited test laboratories representations
- Environmental factors?

Regulatory Challenges – Production

2nd Production

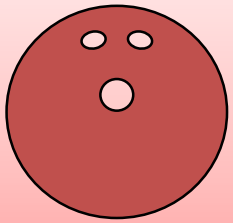
Production Requirements

- 14 CFR / CS 2x.605 – Fabrication Methods – The methods of fabrication used must produce a **consistently** sound structure.
- Production Control System – Organisation needs to have procedures for i**n process inspection** and means of dealing with non-conformed parts.
- Workforce needs to be **trained** to operate the machine in a controlled environment.
- New **Entrants** / **Mixed** Production



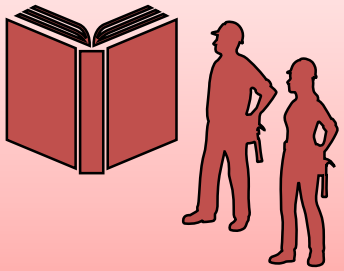
Scalability

- Difference between 1st and 1000th part;
- Batch inspection requirement



Conformity of Part

- Drawingless manufacturing;
- Inspection of geometries that are covered or hidden from view



Training

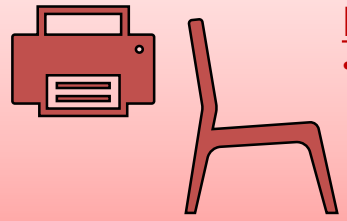
- Machine operator;
- Regulators;
- New Entrants

Regulatory Challenges – Maintenance

3rd Maintenance

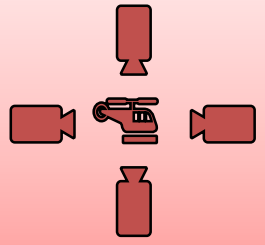
Maintenance Requirements

- Only allows for **fabrication** for modification / repair purposes
- Repair per approved manuals or repair instructions by **Design Organisations** / Designees



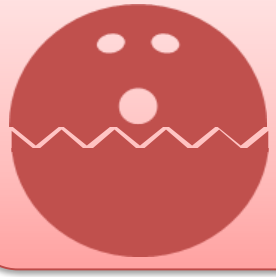
Replacement or Repair?

- Maintenance or production?



3D Scanning

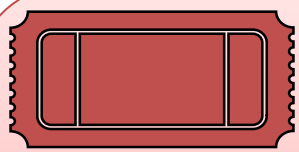
- What are the implications?
- Liability issues?



Cold Spray

- Should the principles on initial certification be applied?

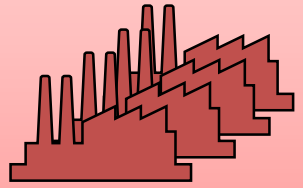
Possible Solutions - 1/2



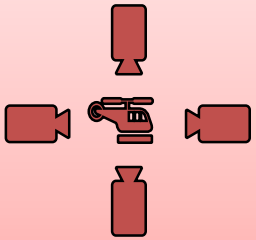
Test Coupon

Test Method / Results

Cold Spray



Scalability



3D Scanning

Possible Solutions

Development of Industry Standards / Authorities

- ASTM F42;
- SAE AMS-AM;
- Singapore Standards Development Council;
- Collaboration amongst authorities (i.e. FAA, EASA, CAAS);

Possible Solutions

Authority or OEM approved 3D scanning

- Embedding production within maintenance;
- Shift of mindset;
- Collaboration amongst authorities (i.e. FAA, EASA, CAAS);

Possible Solutions - 2/2

Conformity of Part

Possible Solutions

Drawingless manufacture

- Cybersecurity equivalent for design, production & maintenance?

In-process inspection

- Technology maturity to incorporate inspection at each print level

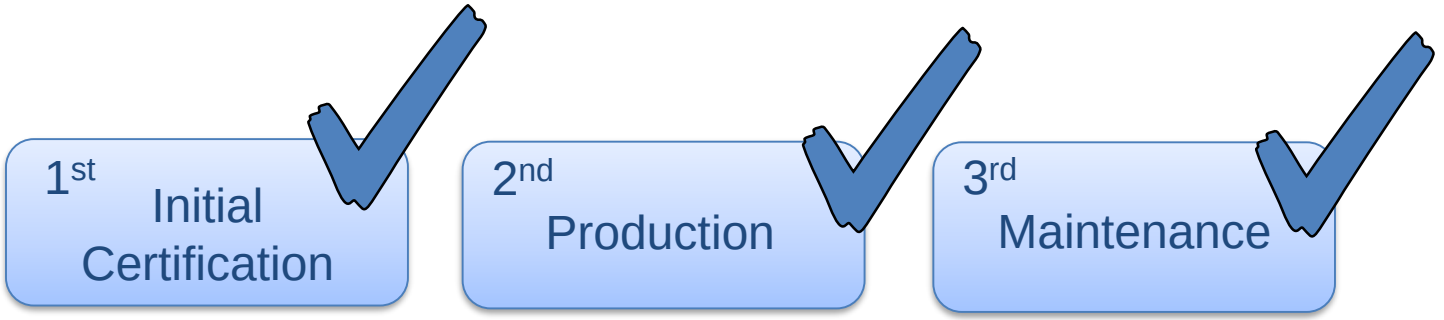
Training

Possible Solutions

Training

- Operator
  - ✓ School syllabus to include additive manufacturing
- Regulator
  - ✓ Concept of AM and understanding of industry standards
- New Entrants
  - ✓ Educate of aviation regulations and expectations

Summary



- Industry working together to develop Standards, with support from Regulators
- Technology maturity to incorporate inspection while printing
- Cybersecurity equivalent for design, production and maintenance
- Training of AM concept in schools, not at work
- Shift of mindset, embedding production within maintenance.

Thank you