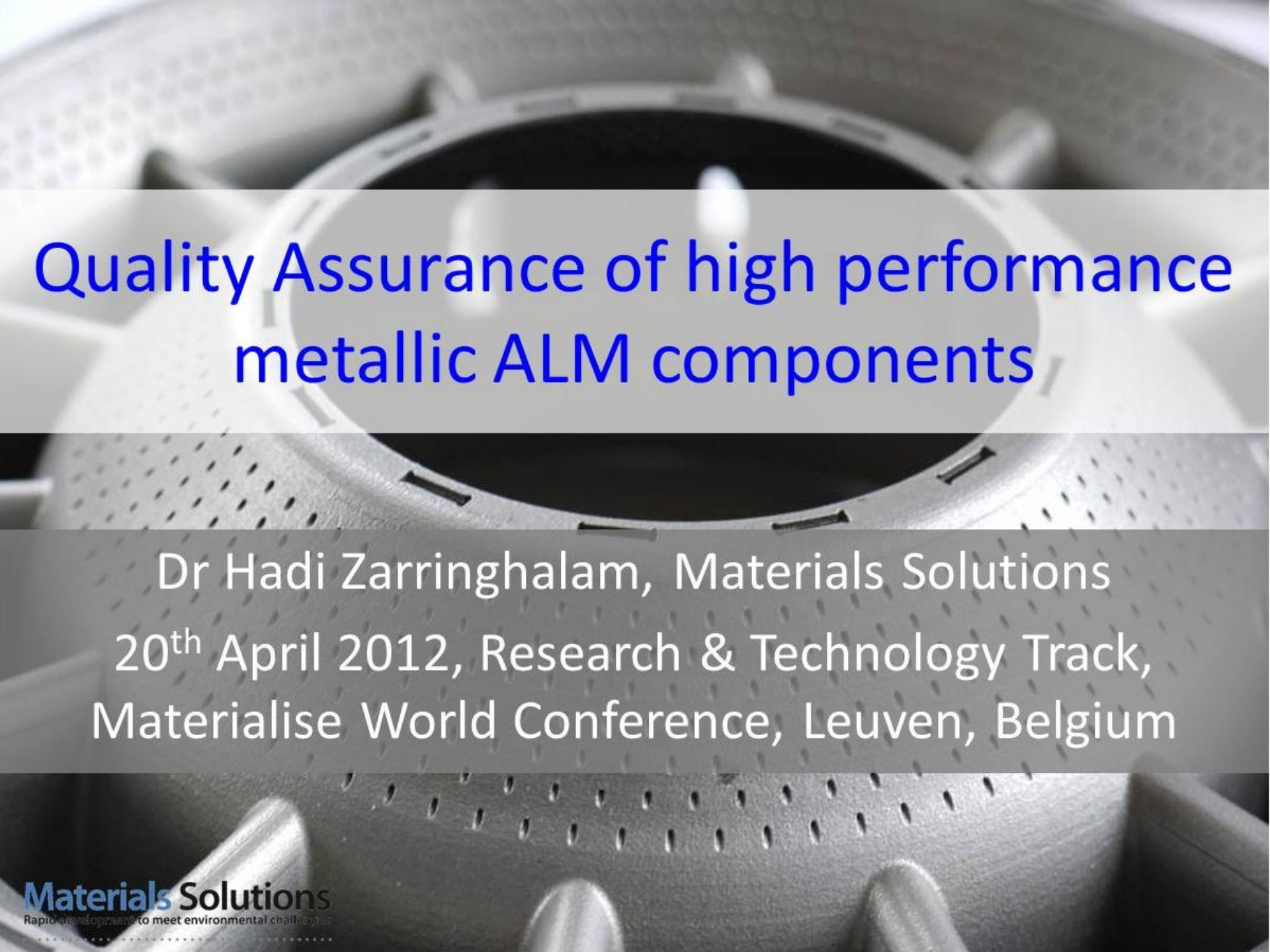


Quality Assurance of high performance metallic ALM components

Dr Hadi Zarringhalam, Materials Solutions

20th April 2012, Research & Technology Track,
Materialise World Conference, Leuven, Belgium

Materials Solutions
Rapid development to meet environmental challenges

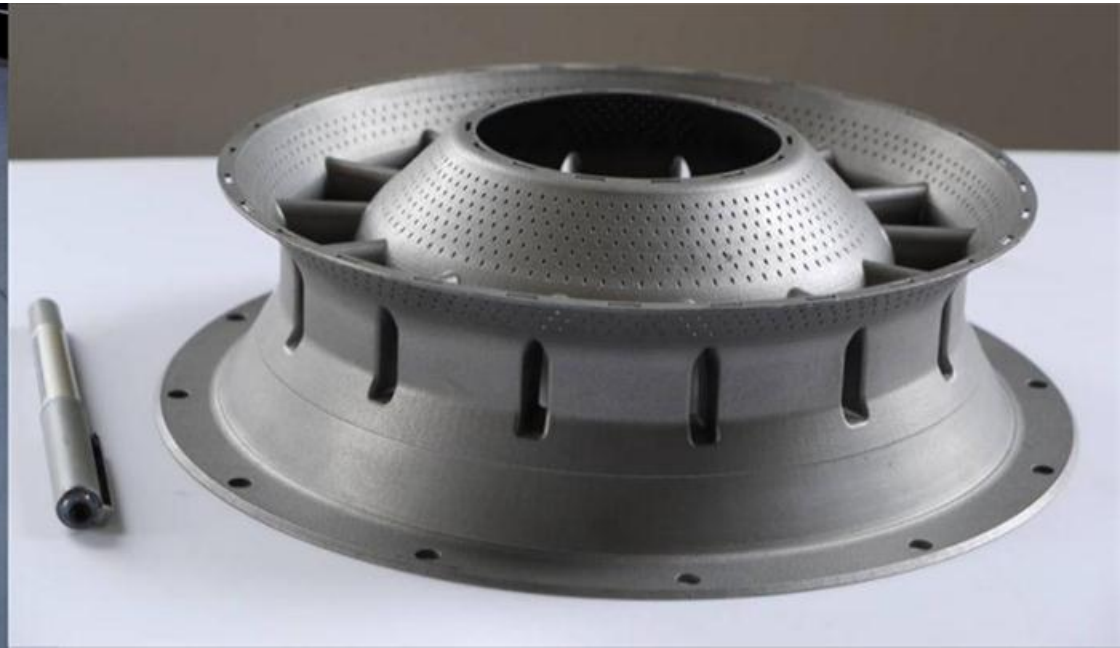
Today's talk

1. Introduction to Materials Solutions. 10%
2. Quality Assurance at MS. 60%
3. Example ALM specific QA challenge. 30%

Materials Solutions

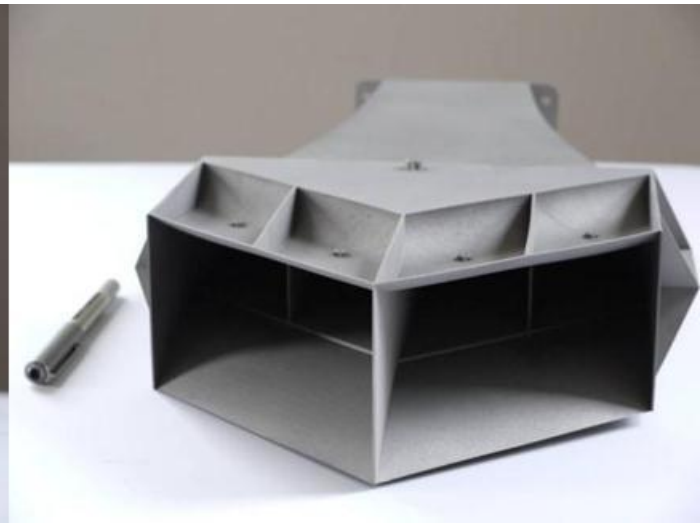
- Materials Solutions is an AS9100 RevC registered ALM parts supplier and consultancy specialising in nickel superalloys and high temperature applications…

  … developing ALM processes **towards production use**.



Materials Solutions

- Markets: **aerospace, F1**, automotive, medical devices, designer goods and others
- ISO 9001:2008 and **AS9100 RevC** .... Multiple customer approvals.
- Experienced quality manager with aerospace background.
- Currently operate **5 EOS M270 DMLS** machines plus a wide range of production, inspection and analytical equipment.



Materials Solutions

- Situated in a purpose-designed factory in Worcester, UK (previously Birmingham)

Materials Solutions: a ‘development factory’

Customer Requirements (drawing, CAD model, SoW etc.) + PO (£,$,€ etc.)

ALM parts

and/or reports

Lift the lid …

Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/
'Precision Engineering' supply partners

Materials Expertise

Extensive inspection capability

Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/
'Precision Engineering' supply partners

Materials Expertise

Extensive inspection capability

Customer Requirements

- Fundamentally we require CAD models to enable the machines to operate …
- However, we make-to-print i.e. customers typically provide an engineering drawing detailing the requirements which we strive to achieve.
- Communication is key. If there is uncertainty over meeting a requirement we inform the customer...

Accreditations and Approvals

- Documented procedures (QMS) and audited practice conforms to key quality standards:
- ISO9001:2008 – general quality
- AS9100 Rev C – aerospace specific
- We expect the same of our suppliers
- Customer approvals based on ISO/AS registration and further audits:

- Rolls Royce (UK, Canada, Nuclear …), ITP, Major motorsport engine manufacturer...

Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/
'Precision Engineering' supply partners

Materials Expertise

Extensive inspection capability

QMS process map

QA

Quality Management System - QD004 - Windows Internet Explorer provided by Materials Solutions

Materials Solutions
Rapid developments to meet environmental challenges

Quality Management System › QD004
ISO9001 / AS9100 quality systems

Recently Modified
QD126
QD123
QD117
QD124
QD125

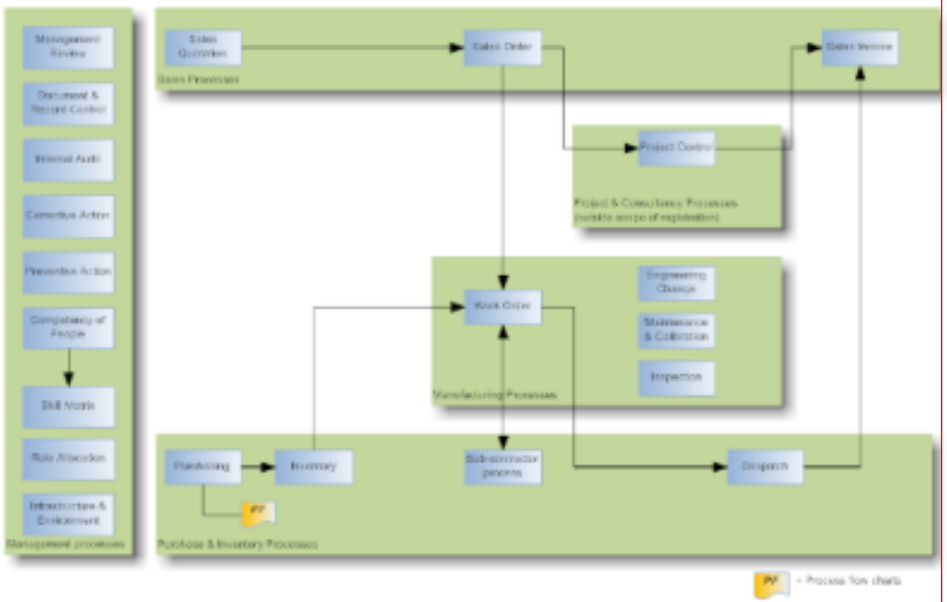
Sites
Top level process map
Quality policy
Quality objectives
Index of procedures
Quality dashboard

Libraries
Audit action
Audit plan
NCRs
Preventive action RAs
Forms
Test certificates
Calibration certificates
Technical query forms

Lists
Audit schedule
Customer feedback
Maintenance register
Improvement log (under development)
Project register
FAIR register
Maintenance Scheduled Tasks
Fixed Asset Spares

Training Records

Top level process map



Revision	Changes	Date	Initial
A	Initial revision.	22/06/07	GG
B	Process map updated.	15/06/10	NM
C	Process map updated.	29/07/10	NM

- Electronic Quality Management System
  - Effectively our formal procedures, written to reflect the requirements of AS9100 RevC
  - Microsoft Sharepoint intranet site.

Materials Solutions
Rapid development to meet environmental challenges

Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/
'Precision Engineering' supply partners

Materials Expertise

Extensive inspection capability

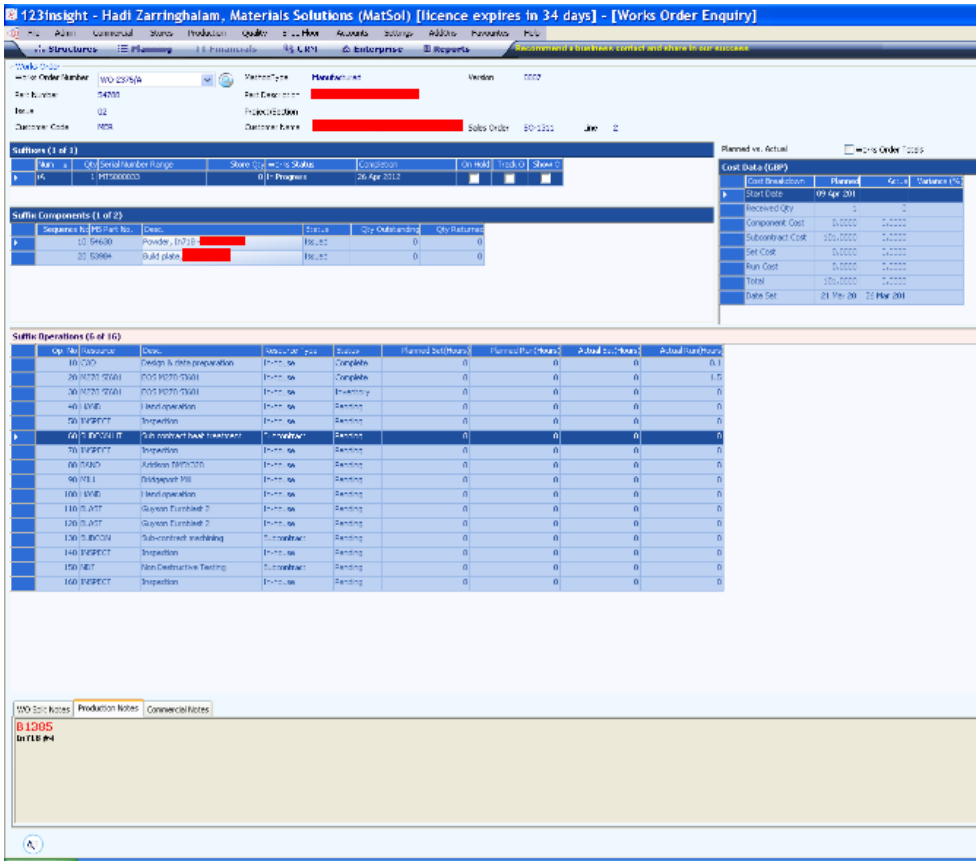
Production Management

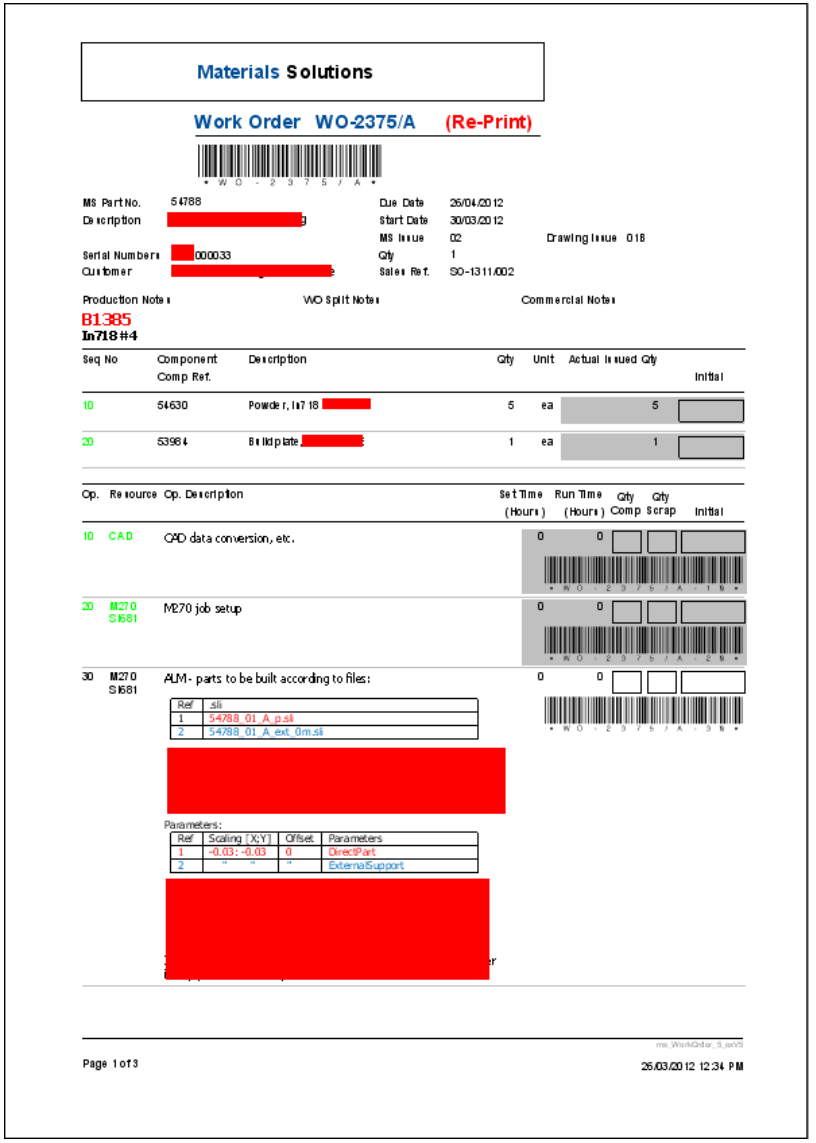
- Production management via 123Insight ERP/MRP/CRM software.
  - Controls: Parts/stock, Work Orders, Sales Orders, Shop floor data collection, Contract Review…
  - Monitor: Status of WIP, Quality metrics e.g. delivery performance…

Contract review

- A detailed contract review, performed on all customer projects, is key to what we do...
- Stand out aspects:
- Drawing review. All requirements identified and reviewed using software tool.
  - *Ensure requirements do not slip through the net*
- Risk Identification and Assessment:
  - *Ensure mistakes are not repeated ... Linked to past NCRS (non conformance reports).*
  - *Identify possible new risks*

Manufacturing control: work orders





Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/

'Precision Engineering' supply partners

Materials Expertise

Extensive inspection capability

Subcon

- **Approved** specialist suppliers
  - Machining
    - EDM, milling, turning, grinding etc.
  - Welding
    - TIG, laser etc
  - Vacuum HT (in-house soon)
  - NDT
    - Dye pen, X-ray, Visual, pressure etc
  - Surface finishing
    - Hand finishing, MMP
  - Coating

QA

Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/
'Precision Engineering' supply partners

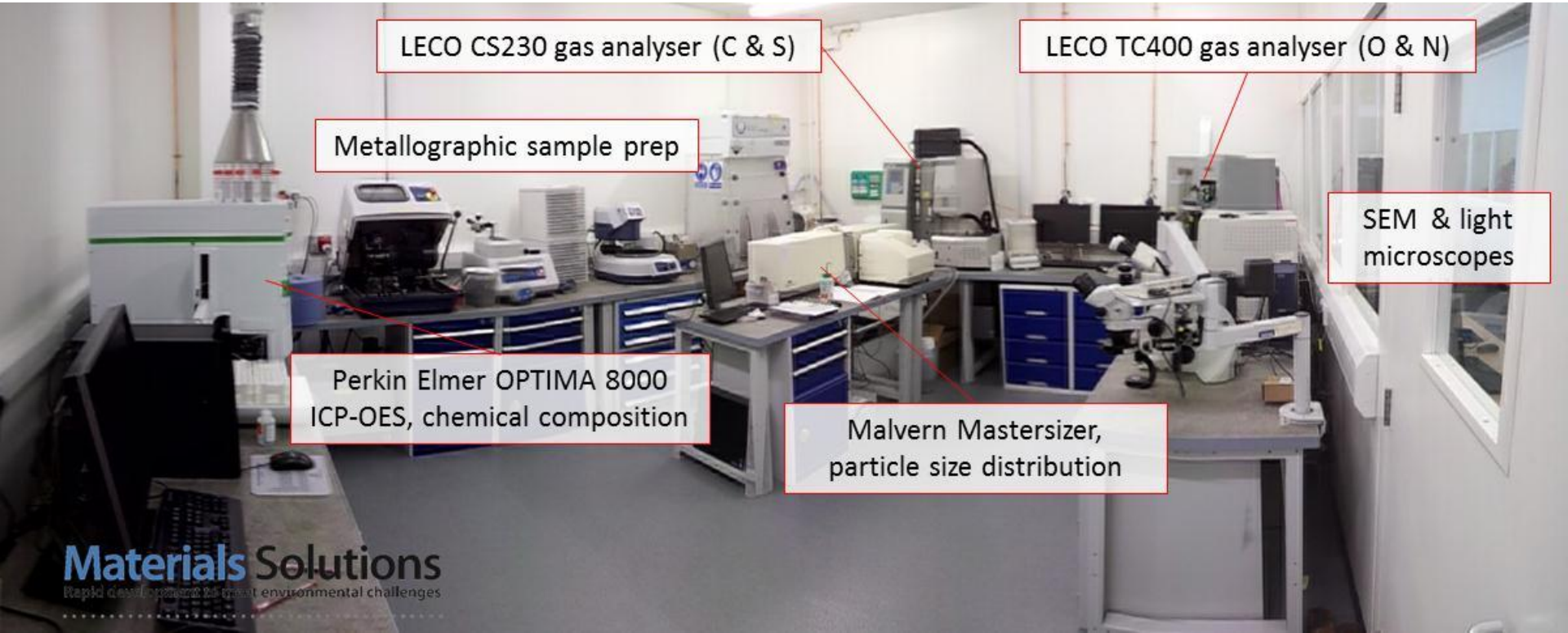
Materials Expertise

Extensive inspection capability

Materials Solutions
Rapid development to meet environmental challenges

Materials development

- Process development
- Validation of properties
- Specification development
- Routine property testing



Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/

'Precision Engineering' supply partners

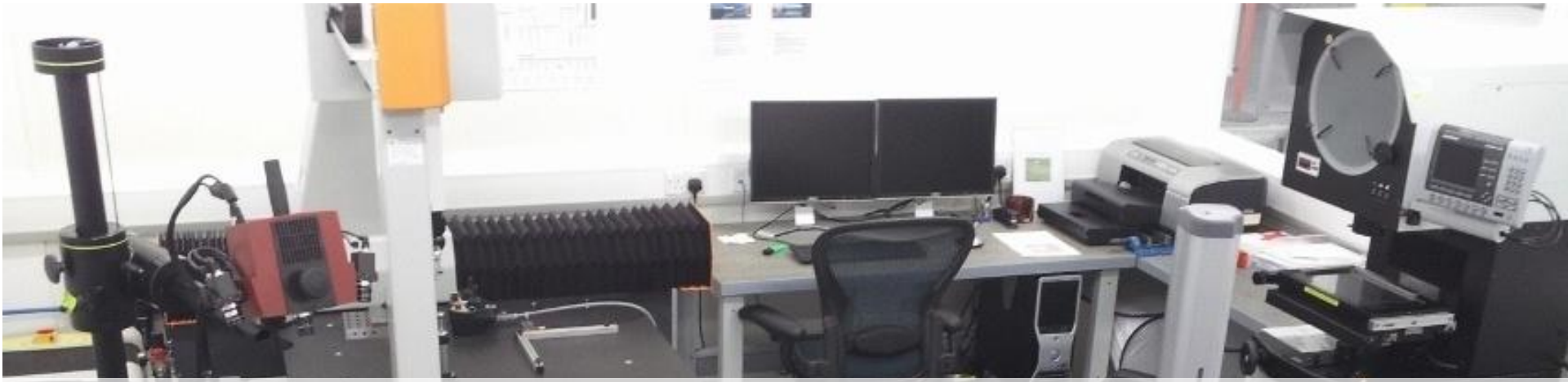
Materials Expertise

Extensive inspection capability

Inspection

- Comprehensive in-house inspection capability … Very little that cannot be inspected .. not just “built to CAD”.
- Our main work horse is a Nikon-Metrology ceramic-construction CNC CMM
- Offline programming to avoid inspection bottle necks

Inspection



- Supported by various tools: GOM ATOS optical 3D scanner, Baty Vertical Profile Projector, TESA digital height gauge, Mitutoyo Surface Roughness tester, wide range of callipers, mics, gauges etc.
- UKAS traceability maintained on equipment via ext. labs
- Air conditioned inspection room

Quality

Strive to meet all
customer requirements

Electronic QMS
(Quality Management System)

QMS Accreditations

Customer approvals

Electronic
Production
Management system

Conventional Aerospace/

'Precision Engineering' supply partners

Materials Expertise

Extensive inspection capability

ALM specific quality challenges

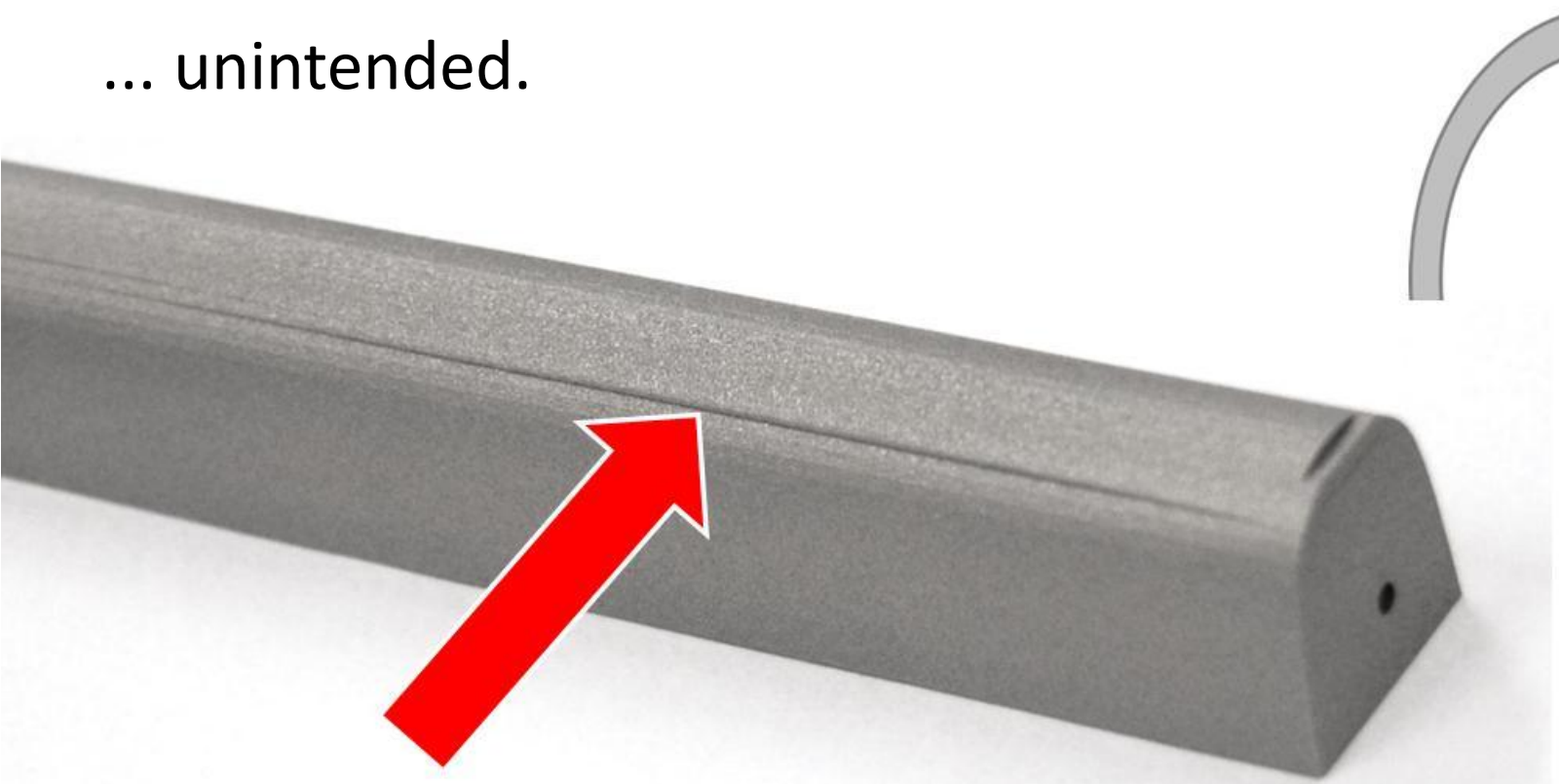
There are many! One example:

- Distortion coinciding with rapid cross-section change.

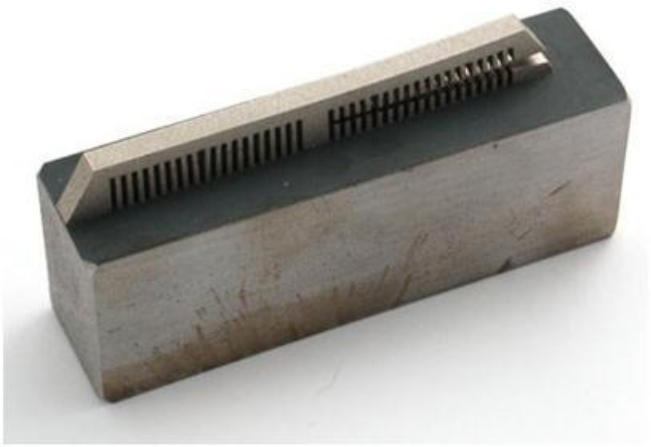
Cross section change distortion

- Peripheral ‘steps’ or ’witness marks’ in parts, parallel to the XY plane

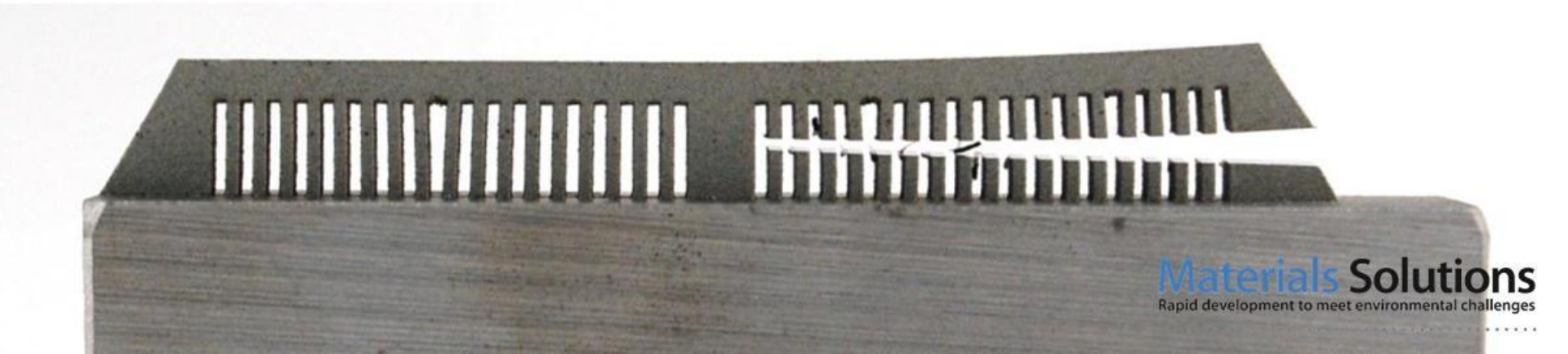
  ... unintended.



Background: massive tensile stresses are generated and act in-build

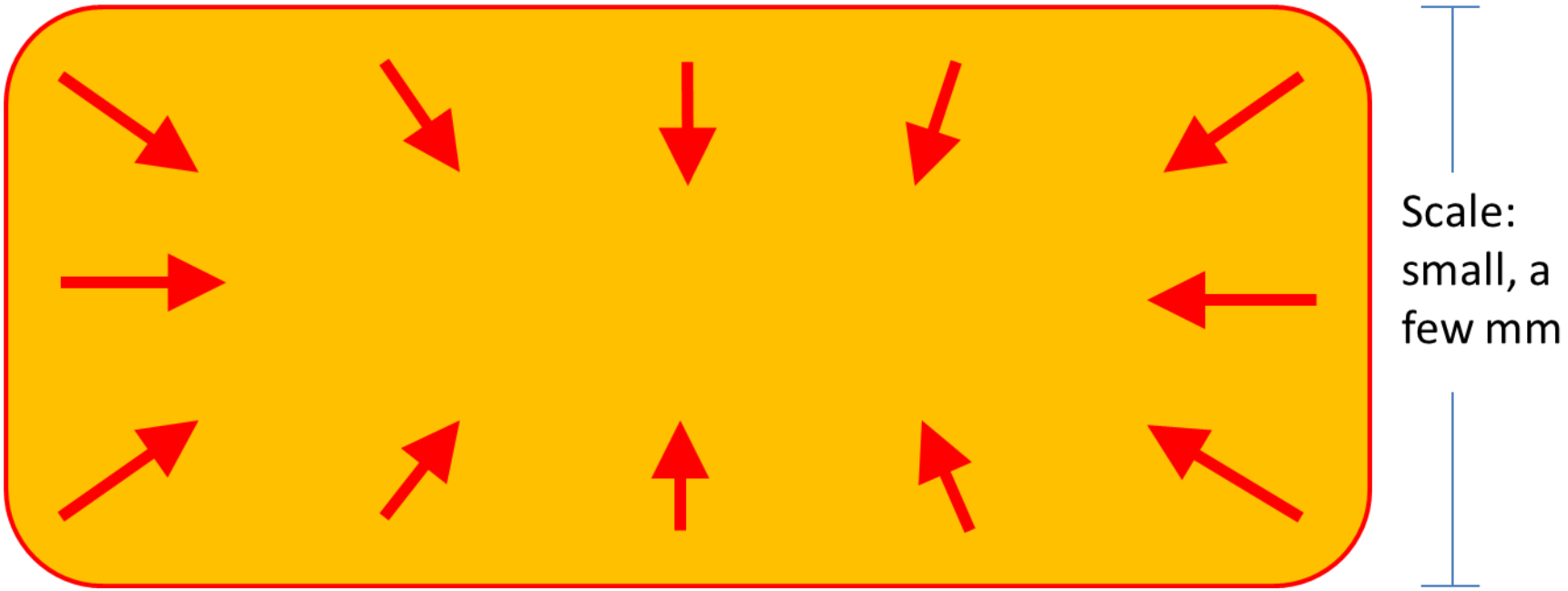


…standard practice is to heat treat parts which causes these stresses to dissipate. The test geometry below demonstrates the effect of cutting a part in the as-built condition with no HT.



Cross section change distortion

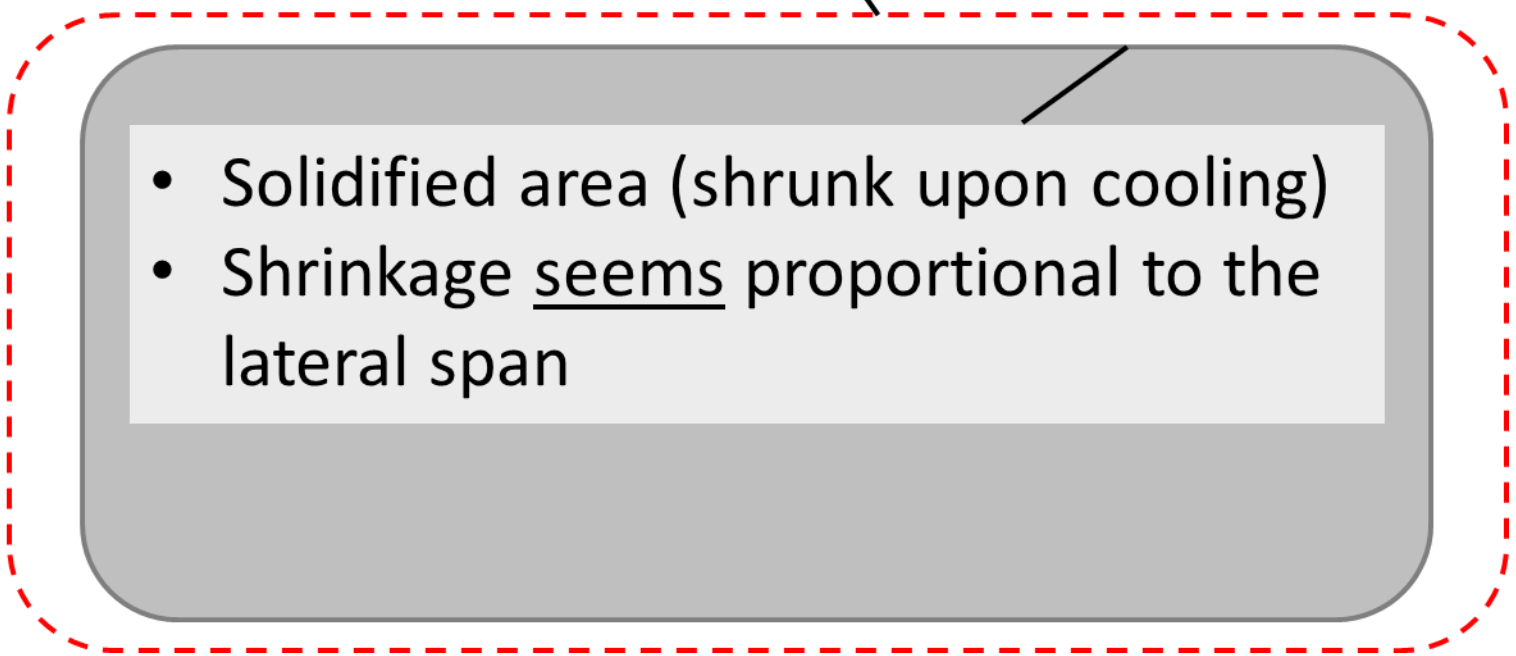
- During build, each molten portion shrinks inwards



(Top-down view …. the laser's point of view)

Cross section change distortion

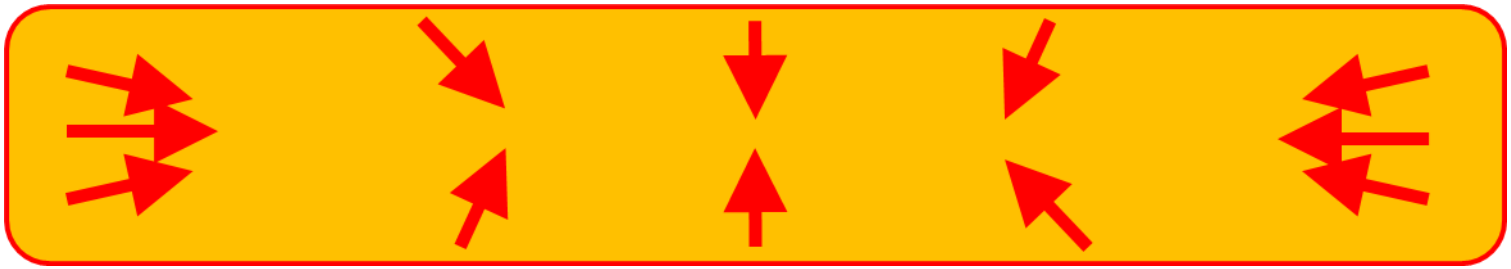
- Original scanned/melted area



Cross section change distortion

- Alternative geometry

  …scanning, melting, shrinking …



Cross section change distortion

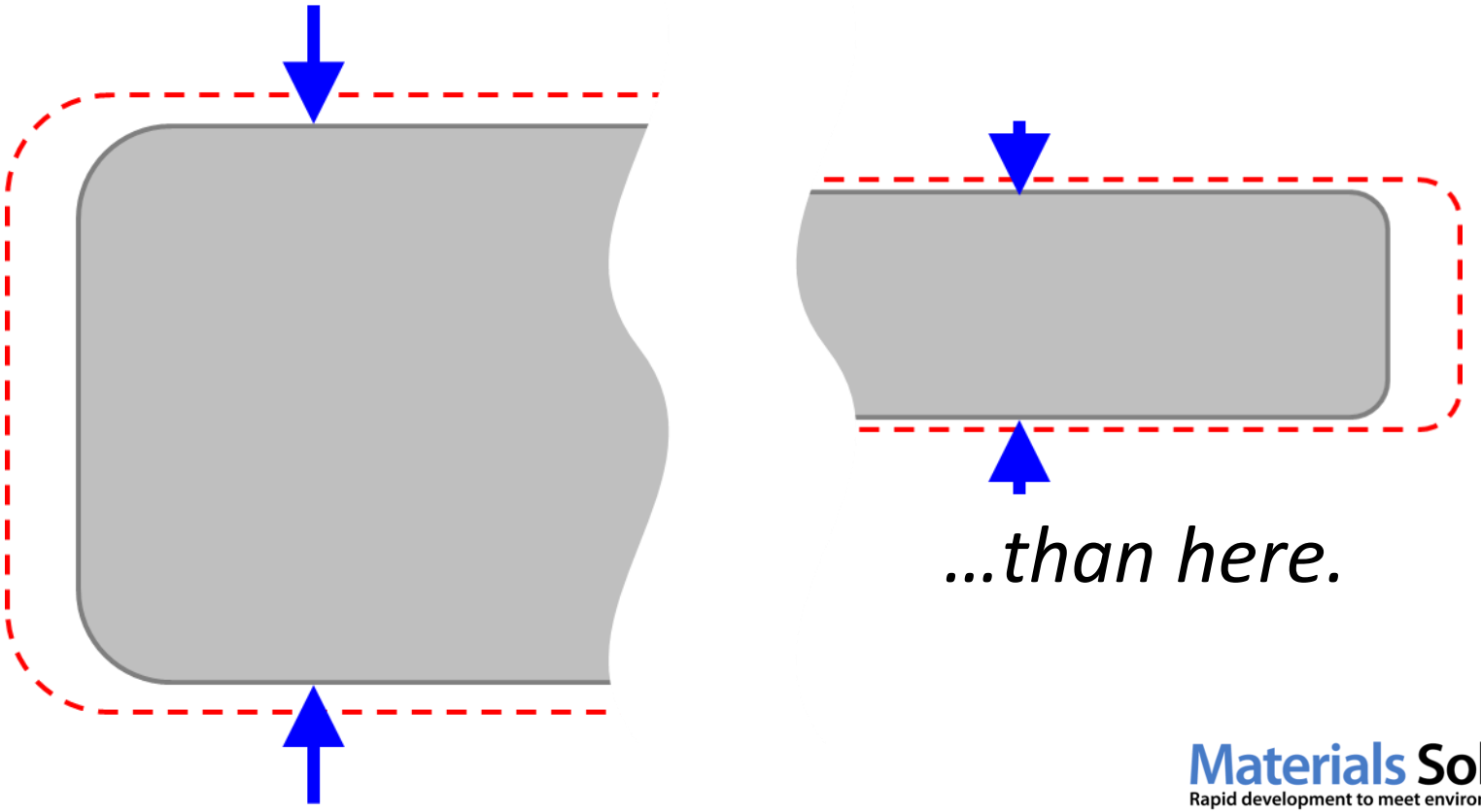
- Alternative geometry

  …shrunk.

Cross section change distortion

- Geometries compared

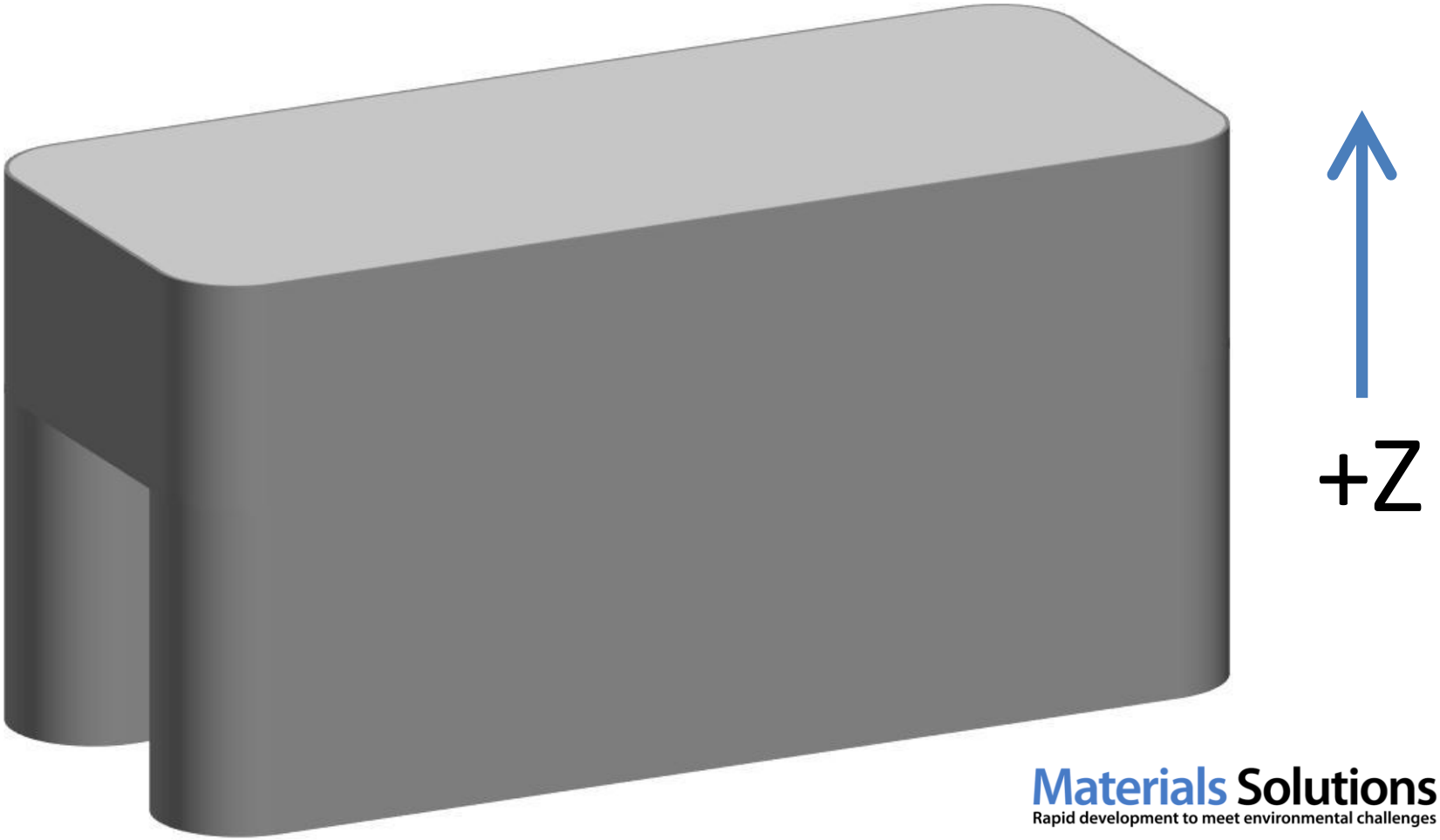
Greater shrinkage here…



…than here.

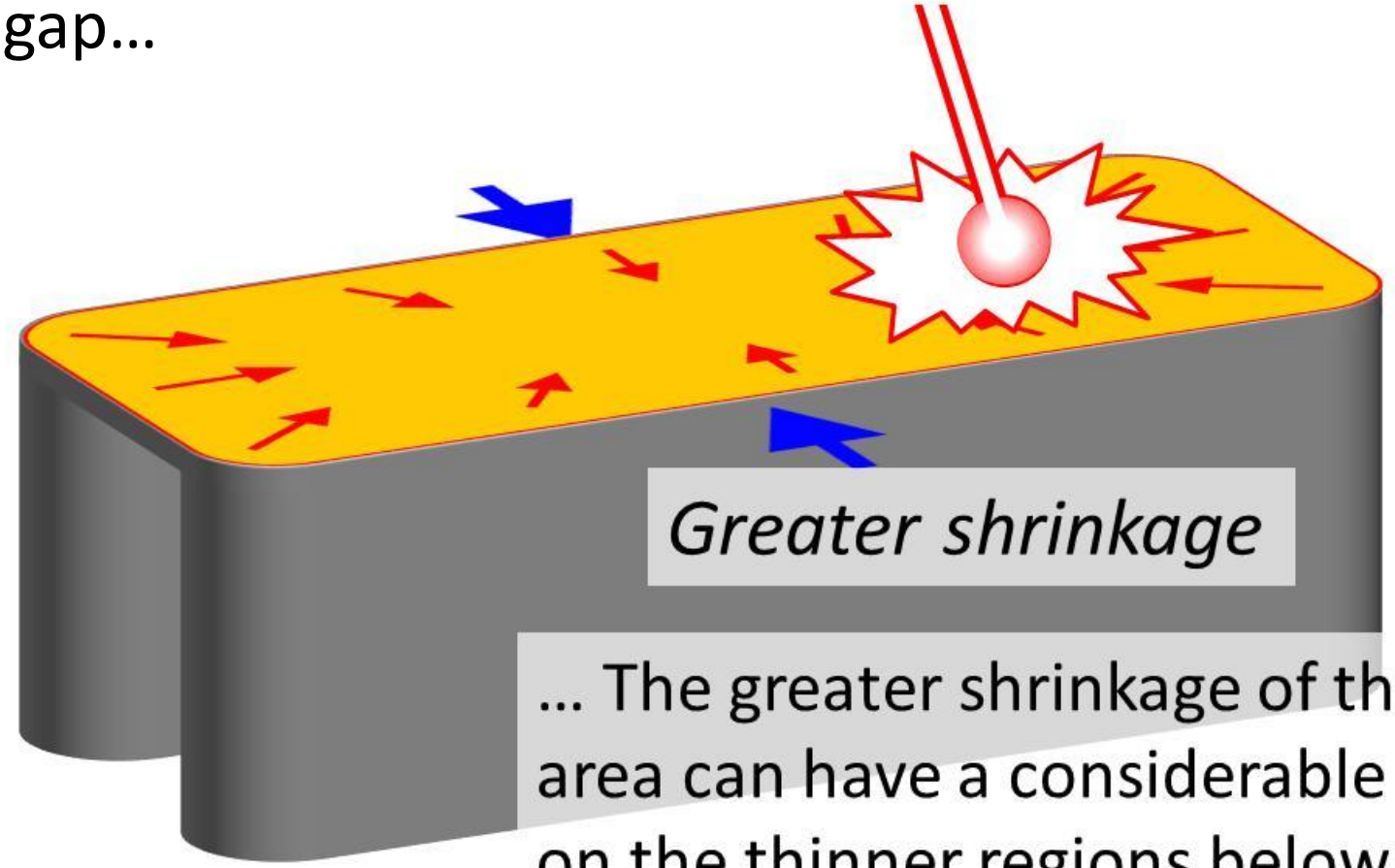
Cross section change distortion

- Consider the two geometries combined



Cross section change distortion

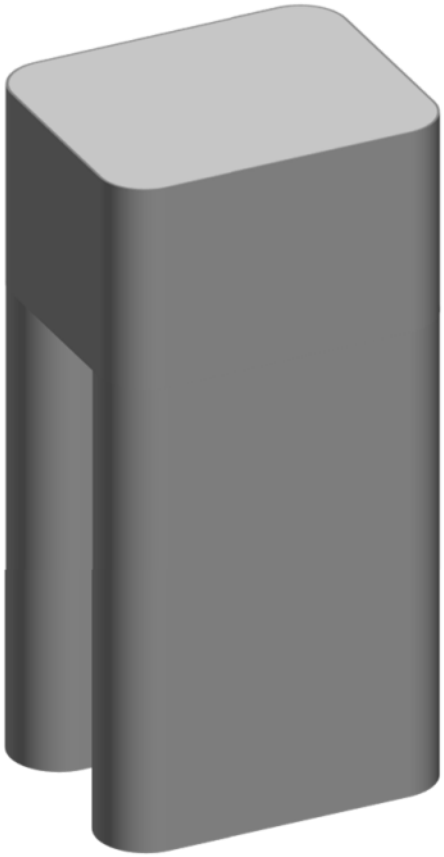
- Mid-build. As the larger cross section is built, it bridges the gap…



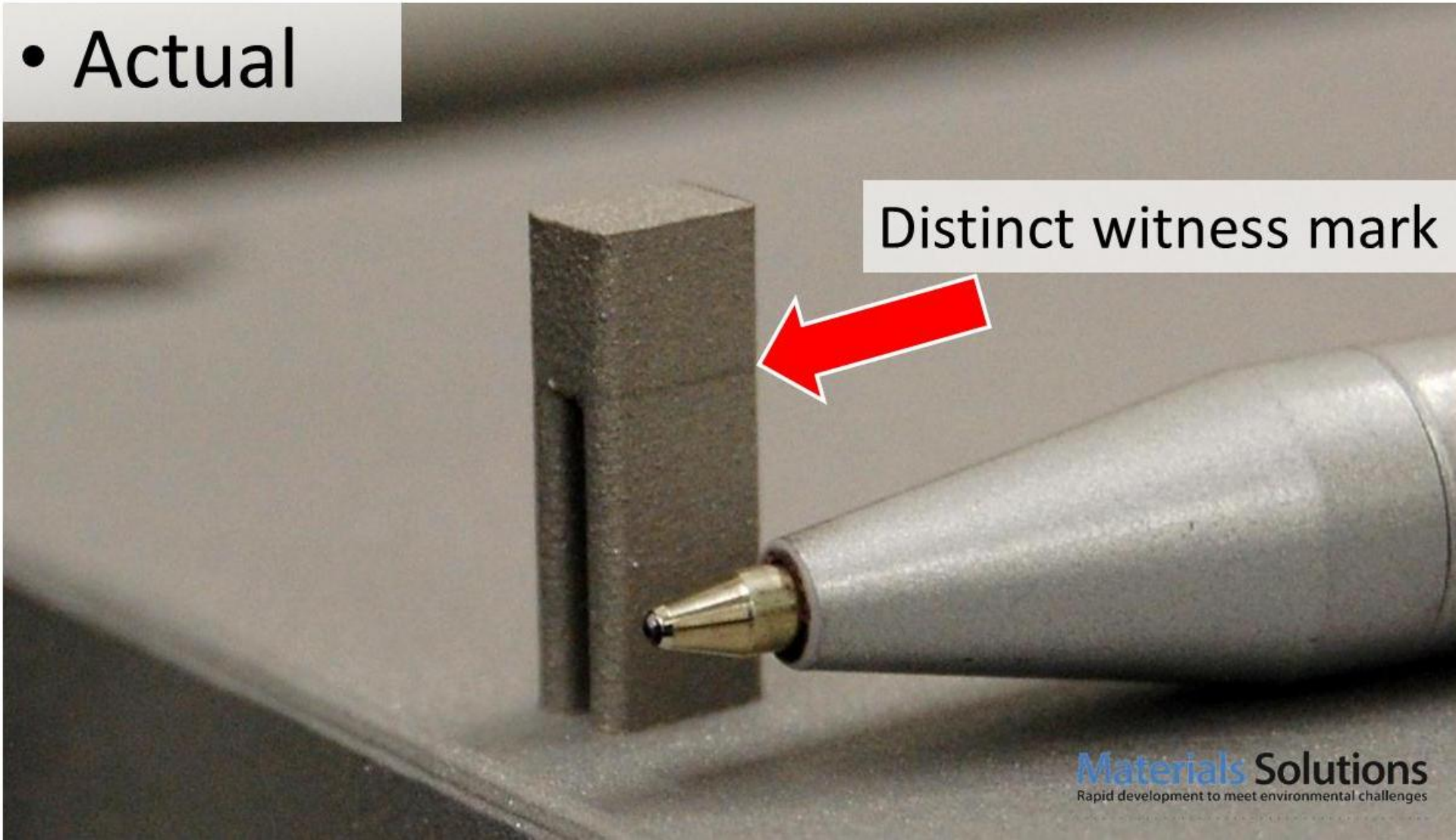
… The greater shrinkage of this larger area can have a considerable effect on the thinner regions below…

Cross section change distortion

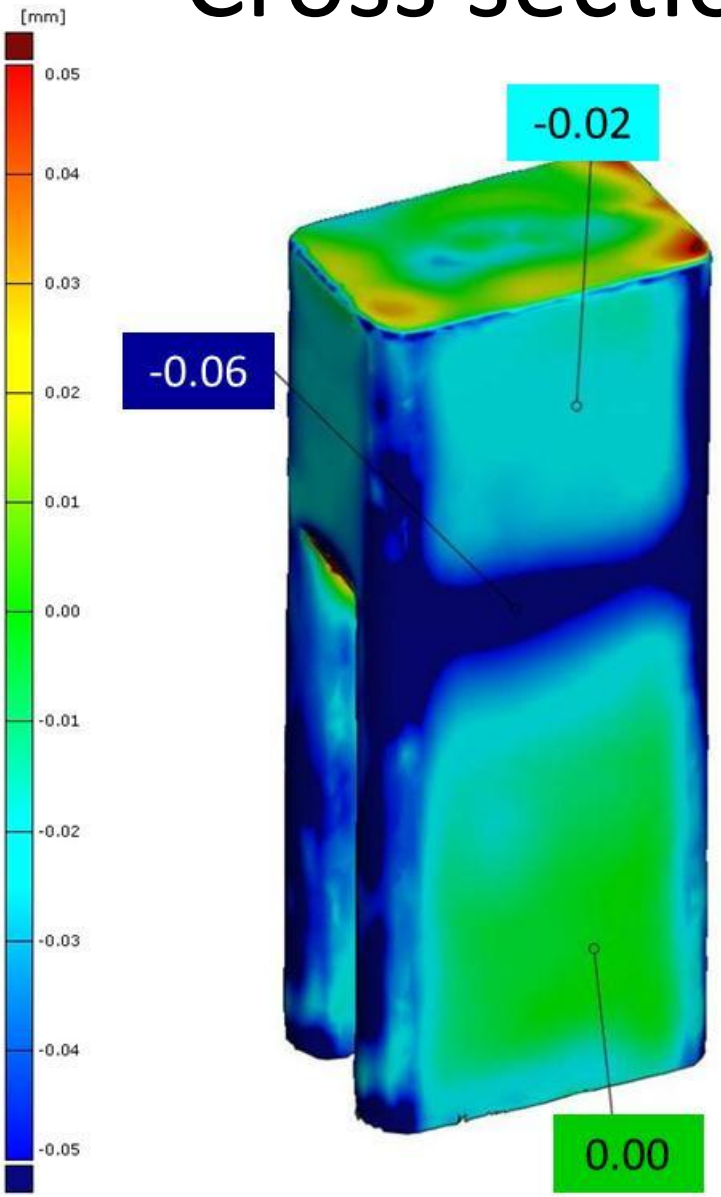
- A similar geometry: Nominal



Cross section change distortion



Cross section change distortion

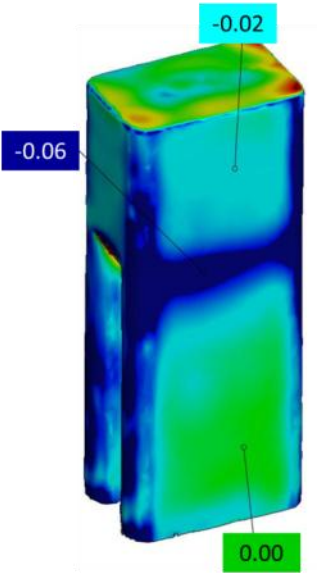


GOM structured-light scan.

Aligned to front face.

60 micron deep step/distortion.

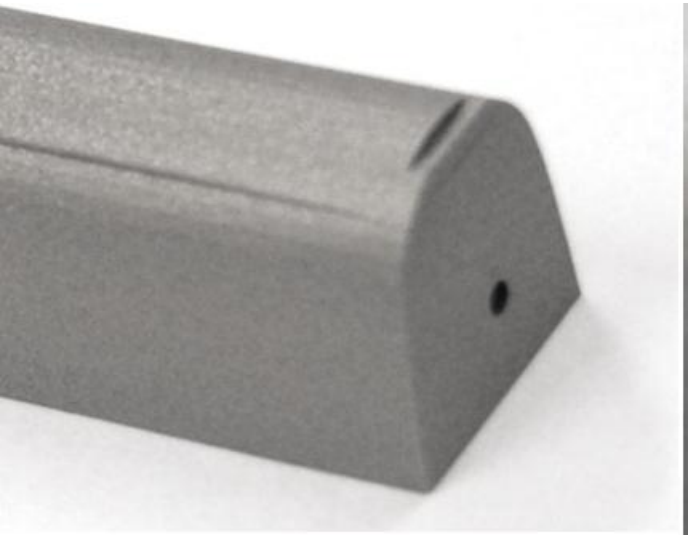
Cross section change distortion



- This is a characteristic of metals ALM *... and similar to those seen with established metal-melting processes such as investment casting.*
- <u>Awareness of such behaviour is key</u>

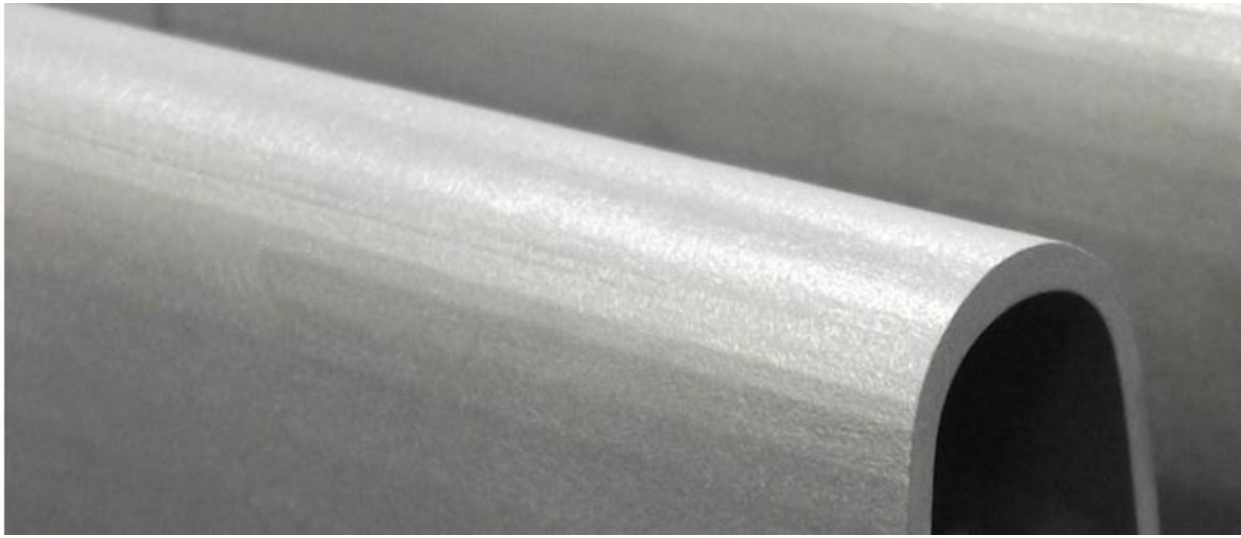
Cross section change distortion

- With careful planning, negative consequences can be eliminated or satisfactorily mitigated.



Trial part,

severe distortion



Final part, distortion greatly reduced

The end is nigh: Conclusions

- Production of ALM metallic parts faces many challenges …as with all other manufacturing processes.
- For some applications (e.g. aero engines), a lot is demanded … especially considering the relative immaturity of the process.

Conclusions

- To meet exacting requirements, carefully implemented rigorous QA practice is essential.
- It is not easy, but done right, the outcome is impressive and the customer is happy.

Thank you

www.MaterialsSolutions.co.uk

+44 (0)1905 732 160