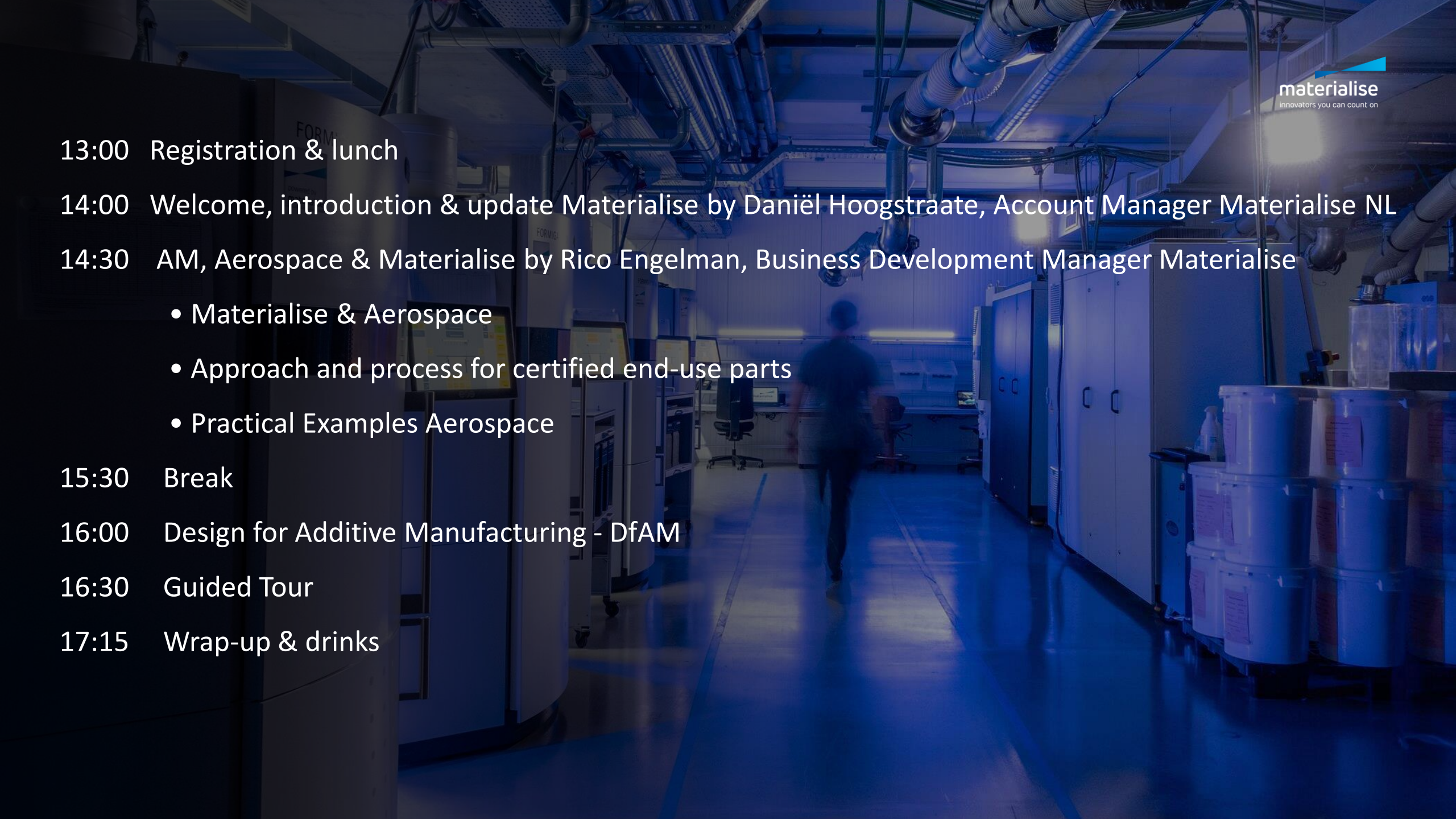
NAG Meeting
3D printing Cluster

22 September 2022

Daniel Hoogstraate | Rico Engelman | Wouter Maleux



13:00 Registration & lunch

14:00 Welcome, introduction & update Materialise by Daniël Hoogstraate, Account Manager Materialise NL

14:30 AM, Aerospace & Materialise by Rico Engelman, Business Development Manager Materialise

- Materialise & Aerospace
- Approach and process for certified end-use parts
- Practical Examples Aerospace

15:30 Break

16:00 Design for Additive Manufacturing - DfAM

16:30 Guided Tour

17:15 Wrap-up & drinks

Leuven 1990..

Growing our expertise, worldwide

materialise
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- ✓ 26 offices in 20 countries
- ✓ +195 3D printers
- ✓ +2000 parts printed daily
- ✓ +2200 employees
- ✓ +210 patents granted
- ✓ +165 patents pending

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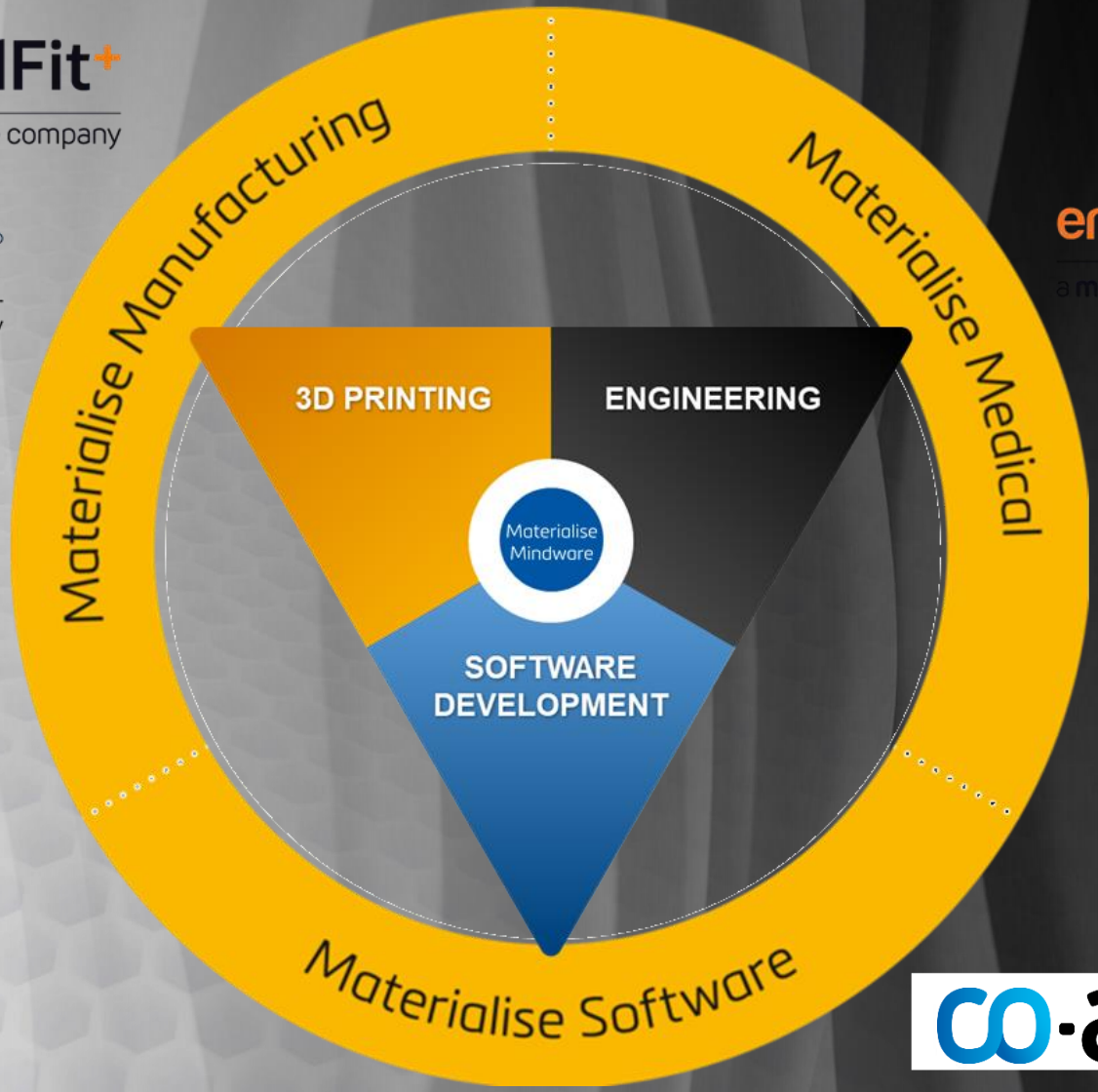
RapidFit+
a materialise company

ACTech®
a materialise company

phits
Custom 3D-printed orthotics



engimplan
a materialise company

co-am

SLA/LS/ MJF/PolyJet/FDM - Leuven

Metal Competence Centre- Bremen

Metal Competence Centre- Freiberg

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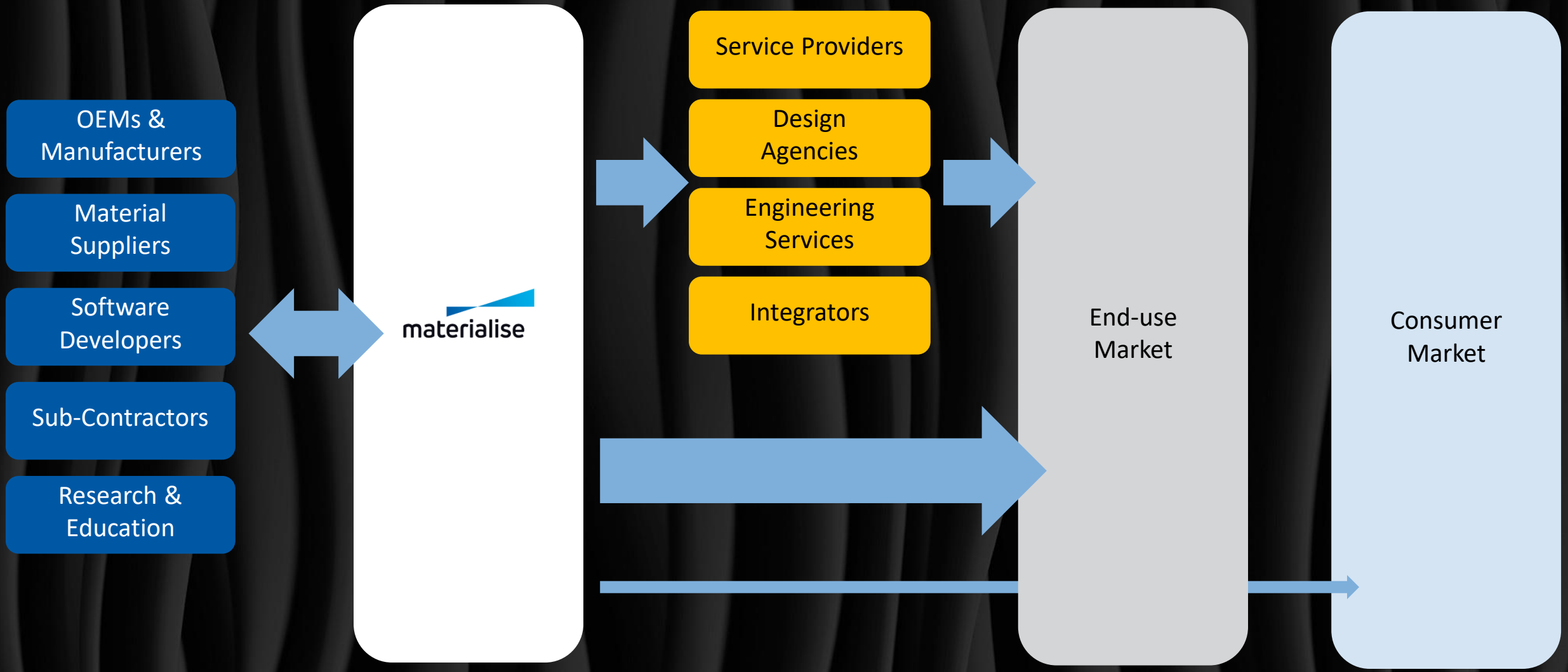
LS & MJF Competence Centre- Wrocław

VC Competence Centre - Ústí nad Labem

Value chain


OEMs & Manufacturers
Material Suppliers
Software Developers
Sub-Contractors
Research & Education
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Service Providers
Design Agencies
Engineering Services
Integrators
End-use Market
Consumer Market

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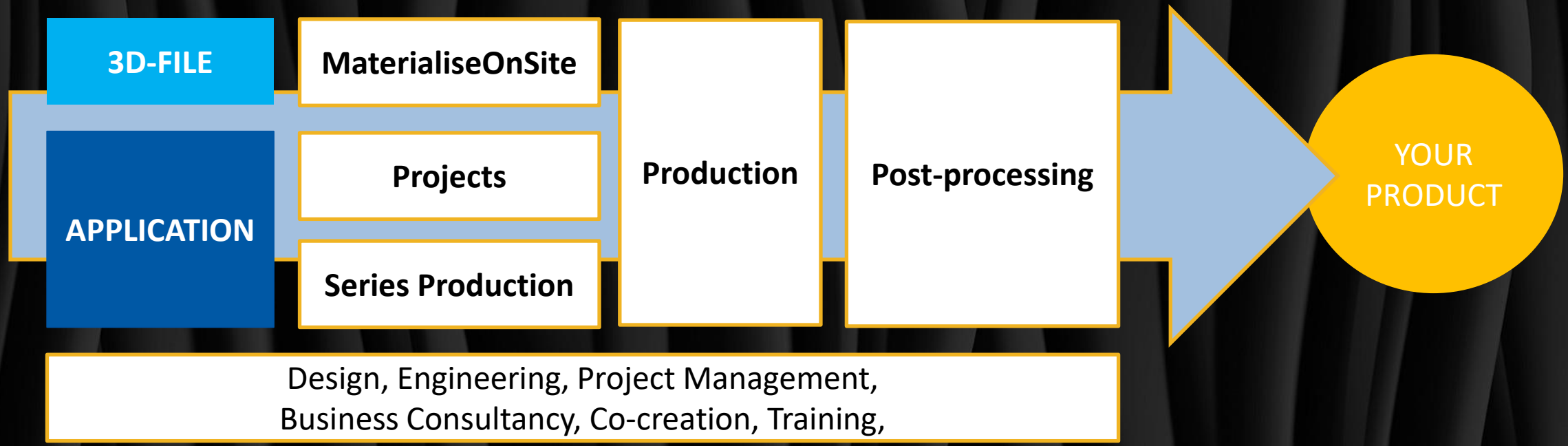

Applications area’s

‘Projects’

Production & Assembly

Series Production

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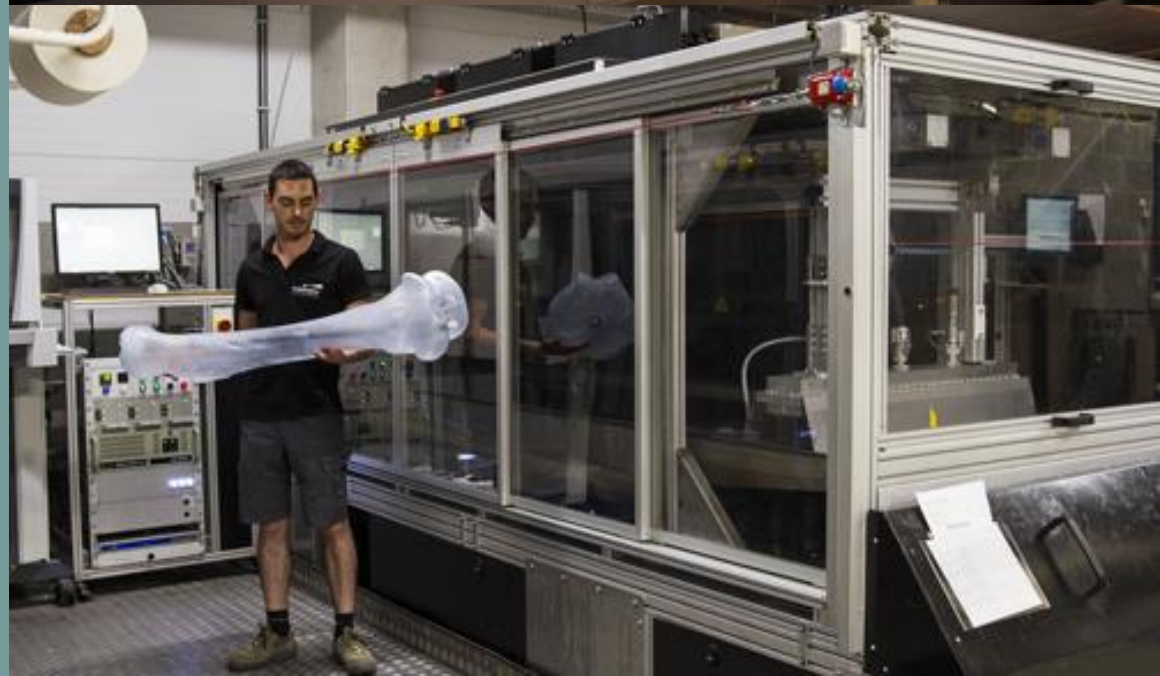

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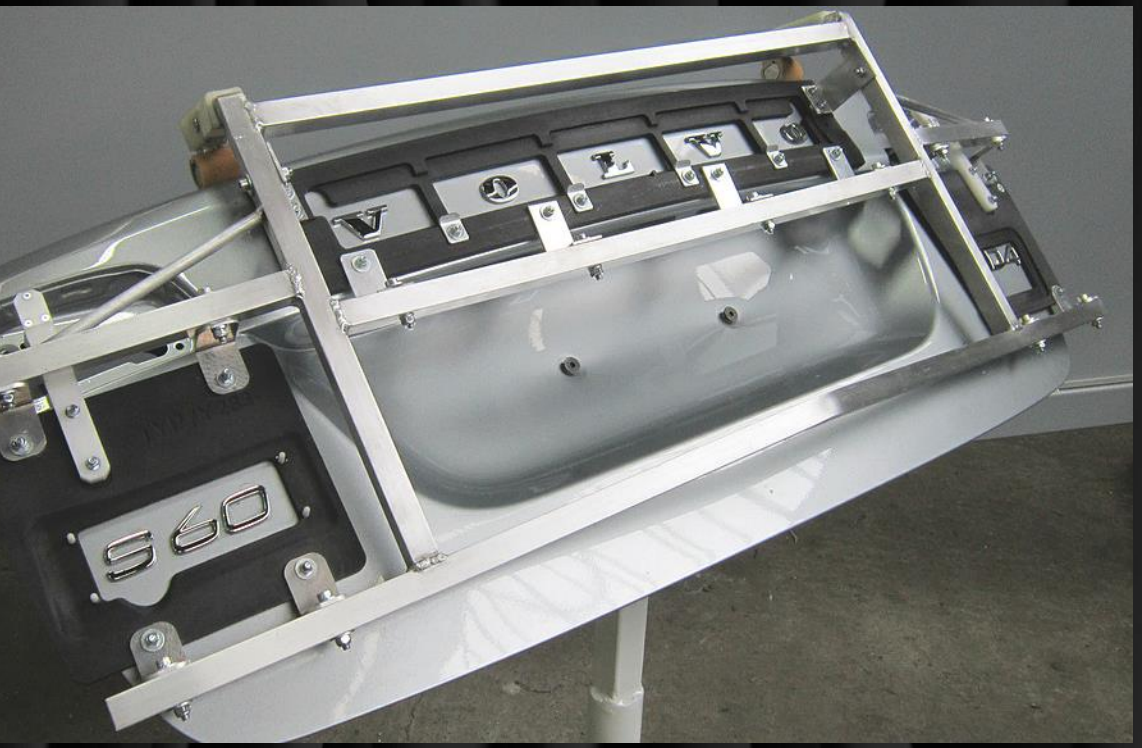

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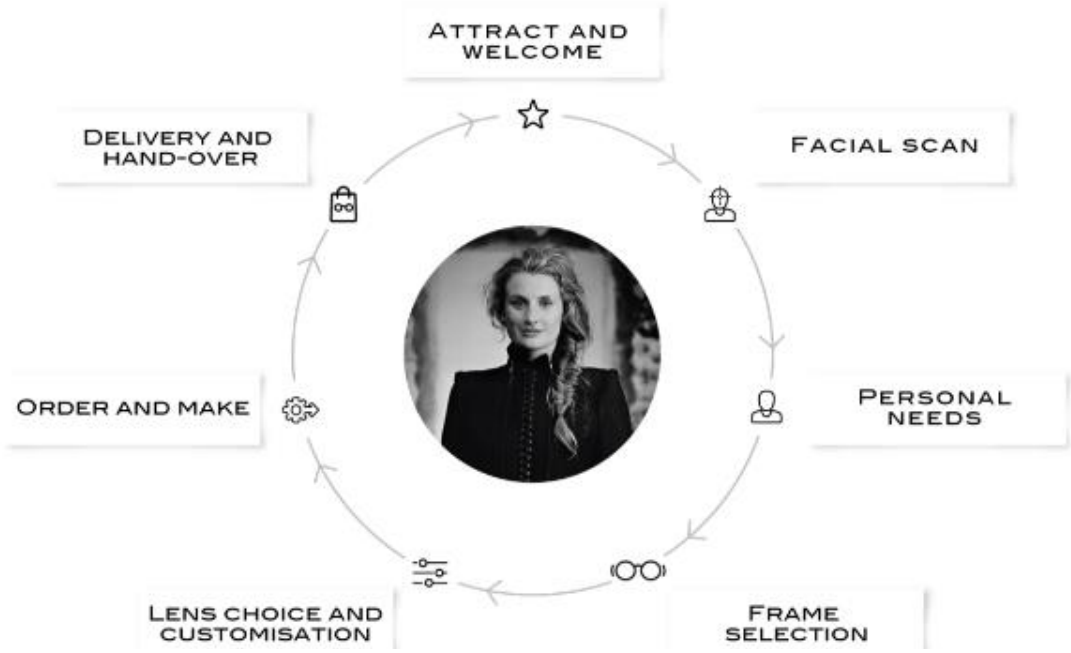
”

With 3D printing’s accessibility, we can offer this technology to more than just the top cyclists competing in the Tour de France. We can offer it to everyone around the world.”

– Maurizio Bellin, Chief of Operations, Pinarello



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Good and bad news about AM-adoption

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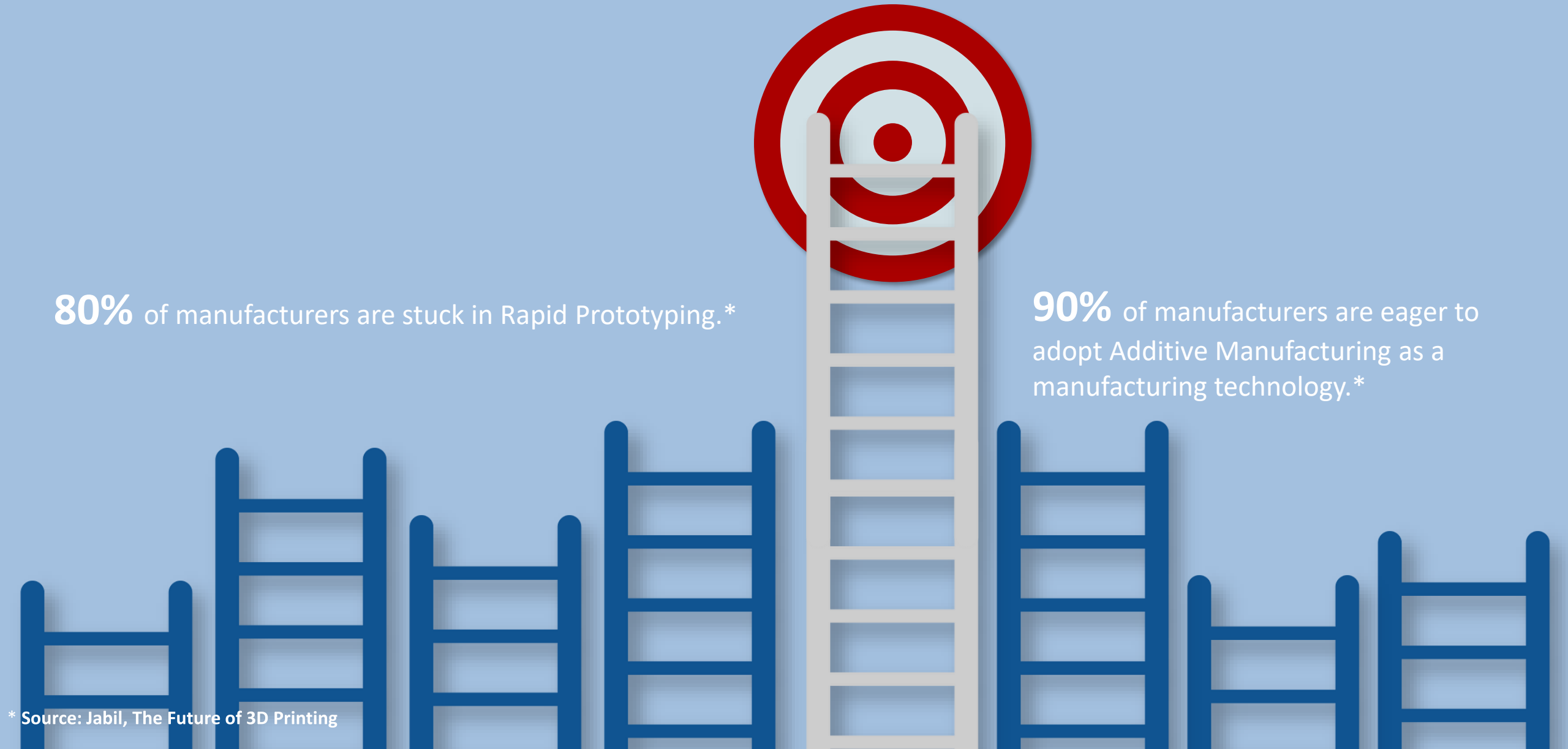
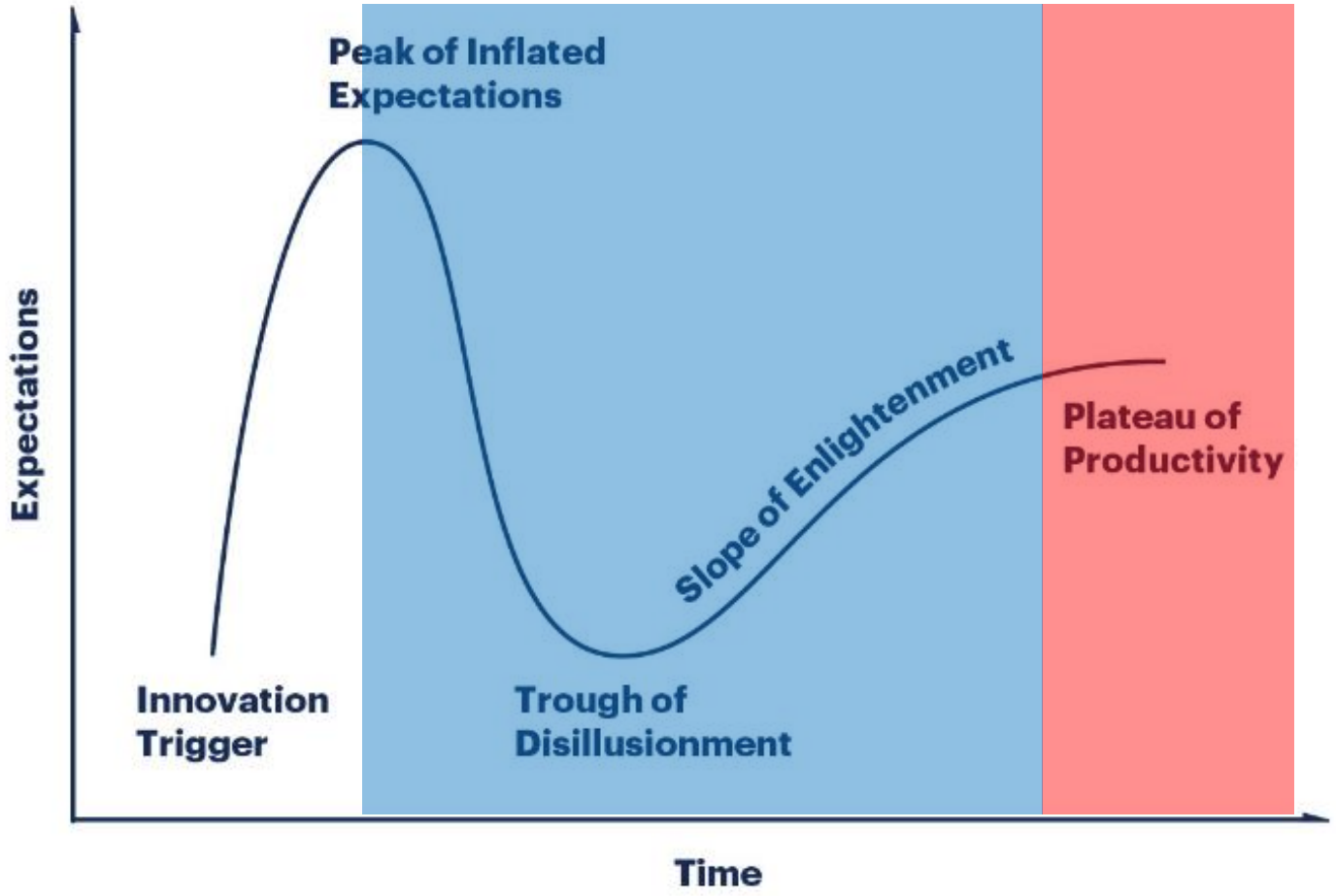
80% of manufacturers are stuck in Rapid Prototyping.*

90% of manufacturers are eager to adopt Additive Manufacturing as a manufacturing technology.*



* Source: Jabil, The Future of 3D Printing



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'Gartner Research's Hype Cycle diagram'

HINDERPALEN VOOR HET TOEPASSEN VAN 3D-PRINTING

Gebrek aan interne expertise en know-how rond AM	45%
Investeringskost	40%
Gebrek aan een business case rond AM of die is niet duidelijk	34%
Huidige technologische beperkingen van AM: productkwaliteit	23%
Huidige technologische beperkingen van AM: productiesnelheid	18%
Gebrek aan certificering en normering	18%
Onduidelijkheid over certificering en normering	18%
Weerstand tegen verandering en innovatie binnen het bedrijf	15%
Huidige technologische beperkingen van AM: (multi-)materialen	14%
Overige:	11%
Huidige technologische beperkingen van AM: productgrootte	9%
Moeilijke integratie in de huidige operationele werking van uw bedrijf	5%
Intellectuele eigendomskwesties	3%

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IMTS
2014


HAUS OF GAGA

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INTERNAL

Time
design & engineering
bridge to tooling

Supply chain
inventories, logistics
lead times

Risk
tooling, pre-series,
single sourcing

Product
topology optimization
weight reduction
reducing parts

Serial production
mass customization
small series

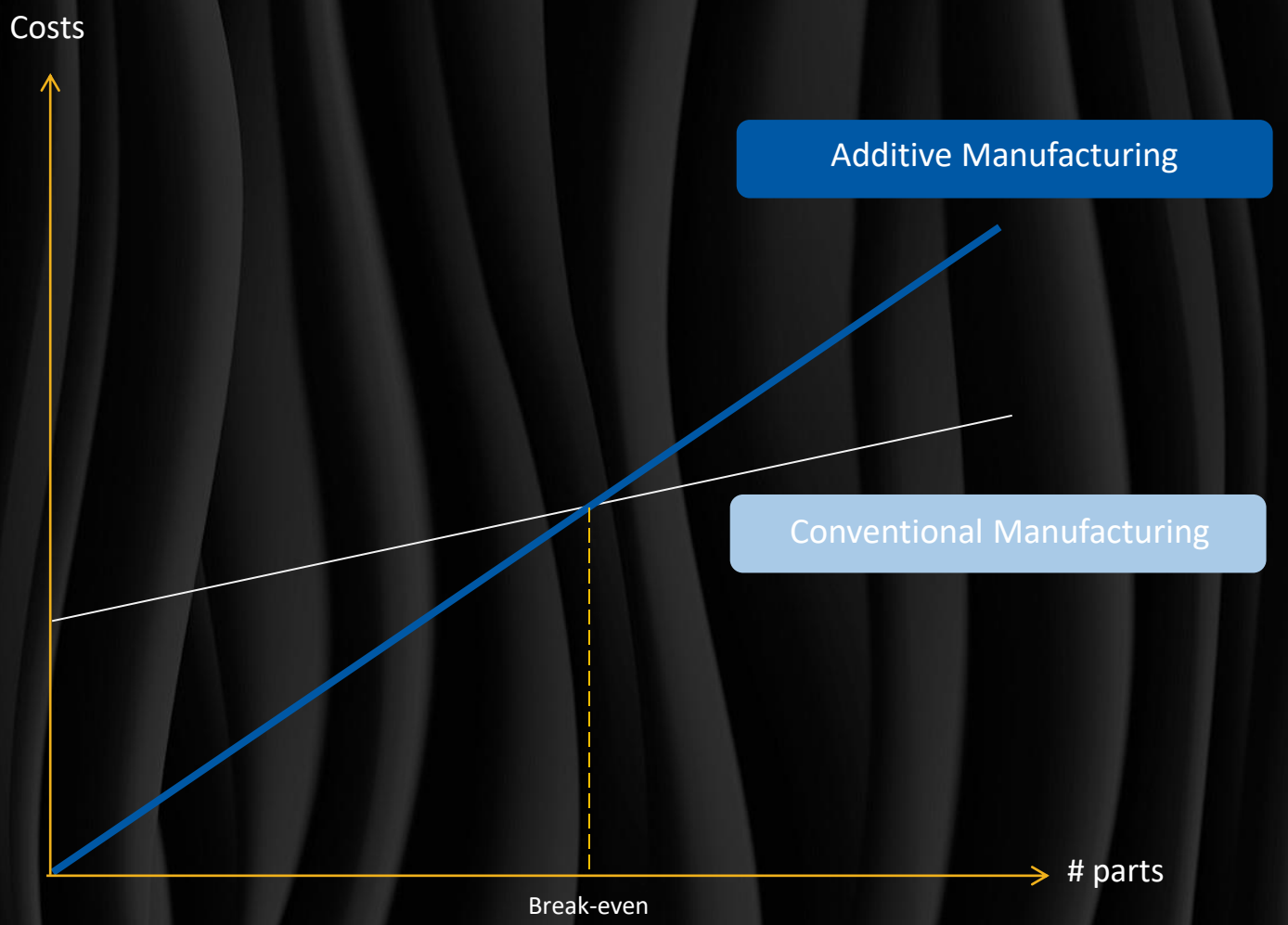
Time
lead times
time-to-market

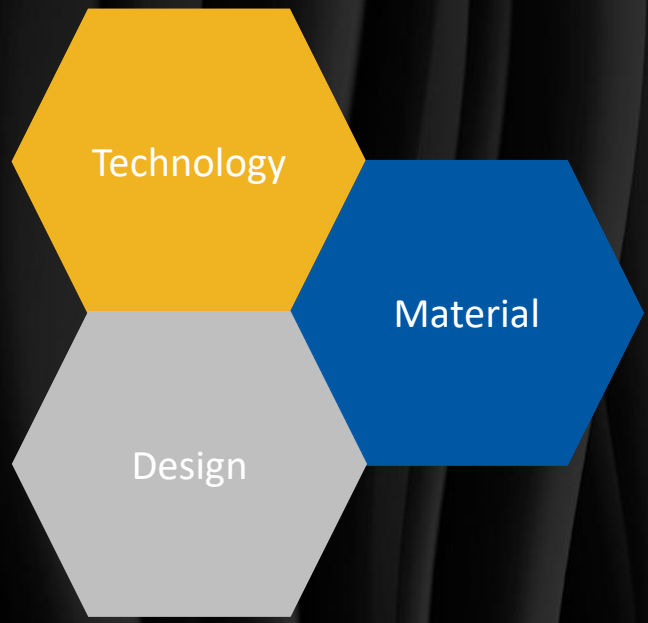
EXTERNAL

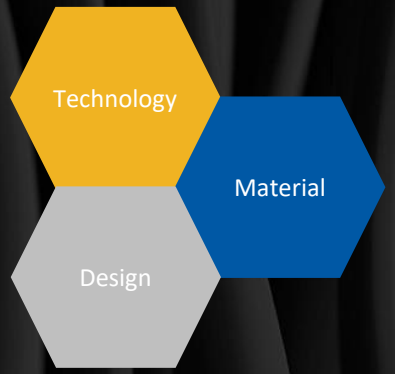
Operational Excellence

Product Leadership

Tipping point







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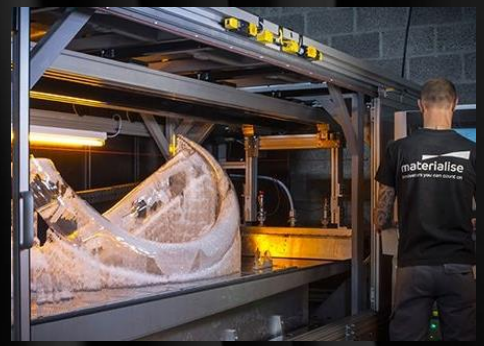
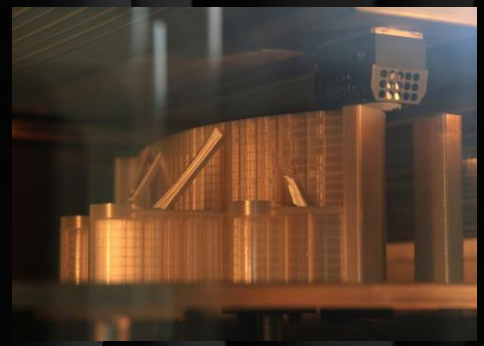
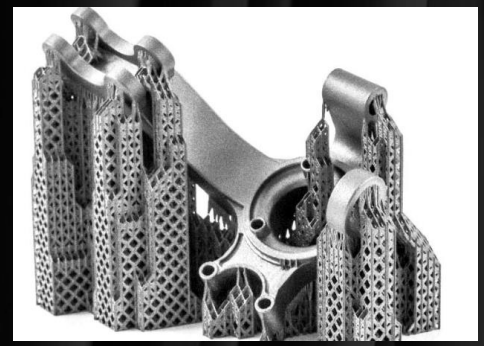
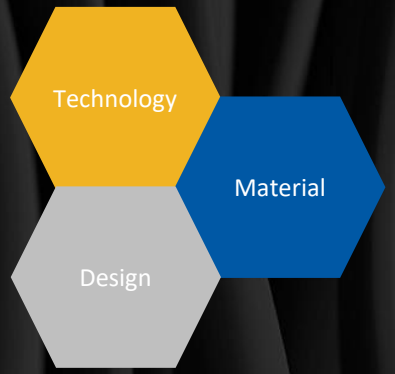
LS Laser Sintering	SLA Stereo Lithography Apparatus	MJF Multi Jet Fusion	FDM Fused Deposition Modeling	SLM Selective Laser Melting
PA, PA-GF, PA-Alu filled, TPU	Epoxy based	PA-12	ABS, PC/ABS, PC, Ultem	AlSi10Mg - TiAl6V4 - 316L – IN718
				



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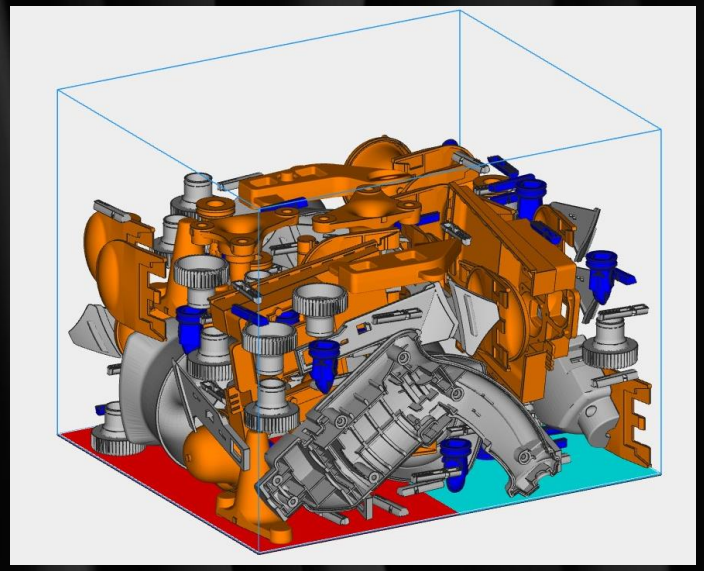
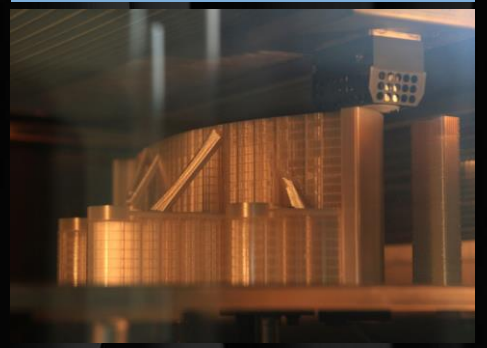
LS
Laser Sintering

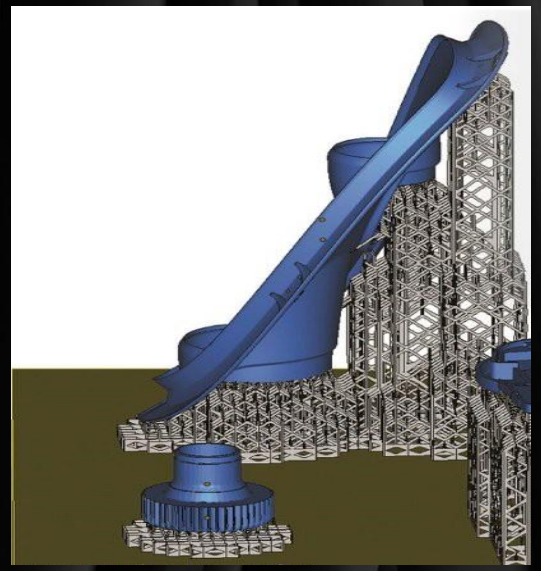
PA, PA-GF, PA-Alu filled, TPU



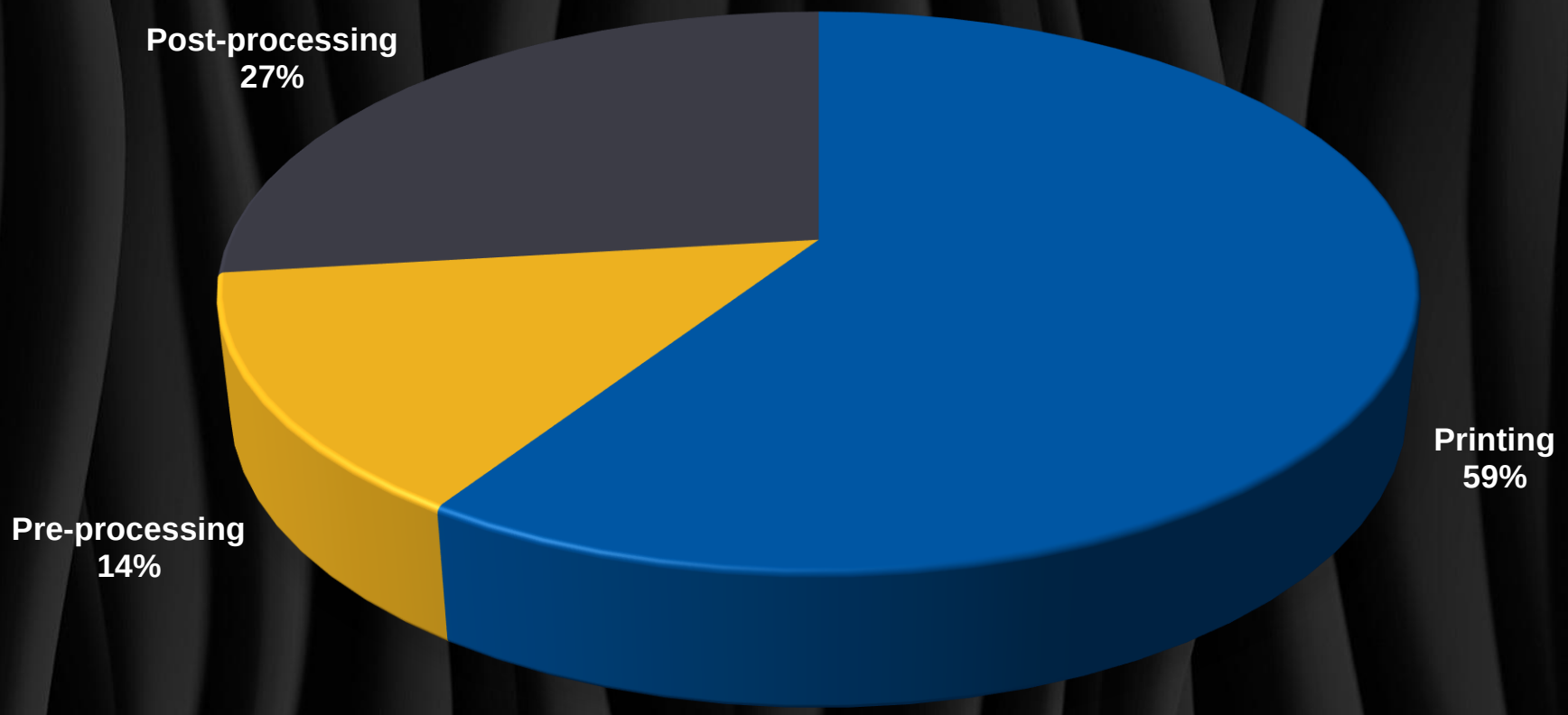
FDM
Fused Deposition Modeling

ABS, PC/ABS, PC, Ultem





Total costs of Additive Manufacturing

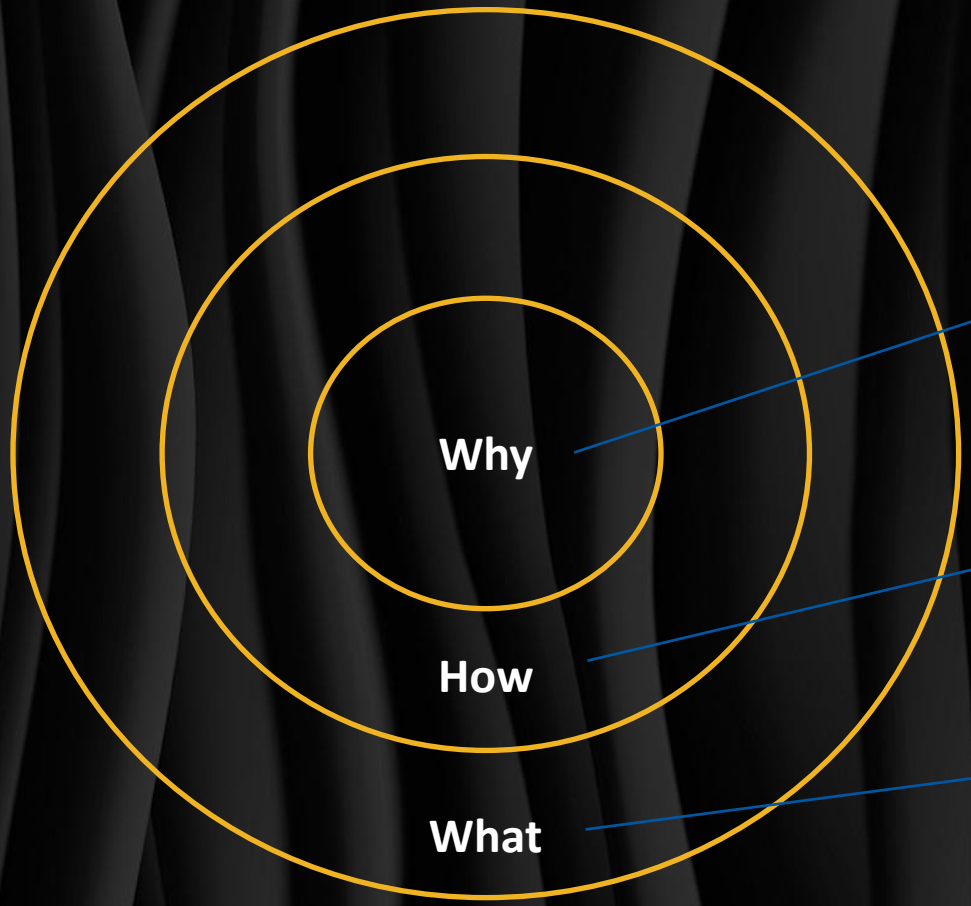


Source: Wohlers Reports 2021

Pitfalls

- Technique as starting point
- Underestimation of complexity
- Re-inventing the wheel

‘Golden Circle’



Application

Pain, Drivers, Challenges

Benefits of Additive Manufacturing

Material, Technique, Finishing, ..

Simon Sinek (‘Start with why; how great leaders inspire to action’)

Aerospace

Additive Manufacturing

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Rico Engelman

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Context and Scope

“AM is risk-taking, but with data comes insurance” (Boeing)

“biggest challenge for AM is to manage variability” (FAA & FDA)

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AM and Aerospace

78% of aerospace companies have used/are using 3D printing for prototyping,

yet only **18% use AM for end-parts** manufacturing (Source: EY 2019)

→ The top cited reason is **qualification challenges**

Scene setting – the state of AM in aero

It's **new**...

"Noting the current novelty of AM use in aviation applications…"

EASA

Scene setting – the state of AM in aero

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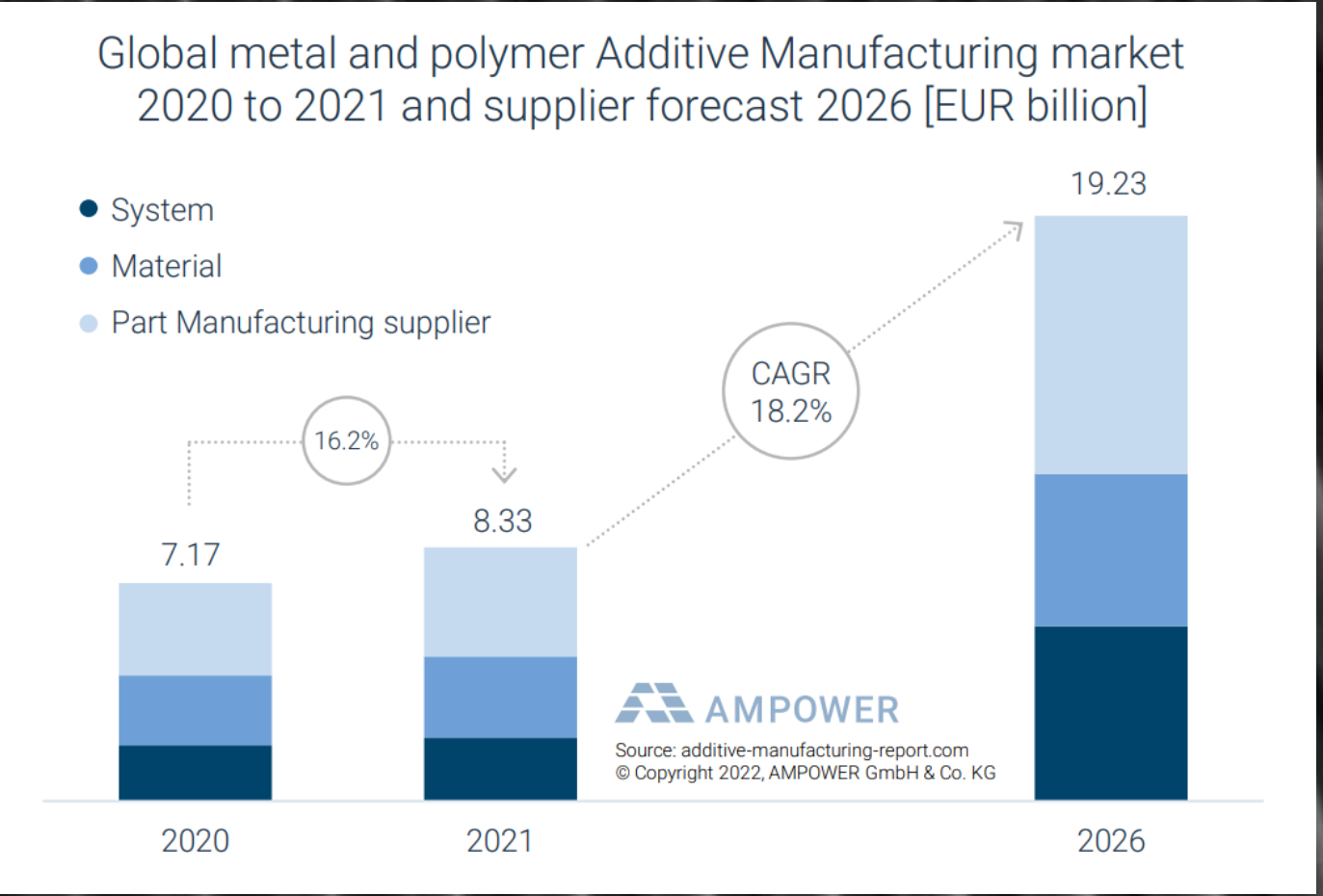
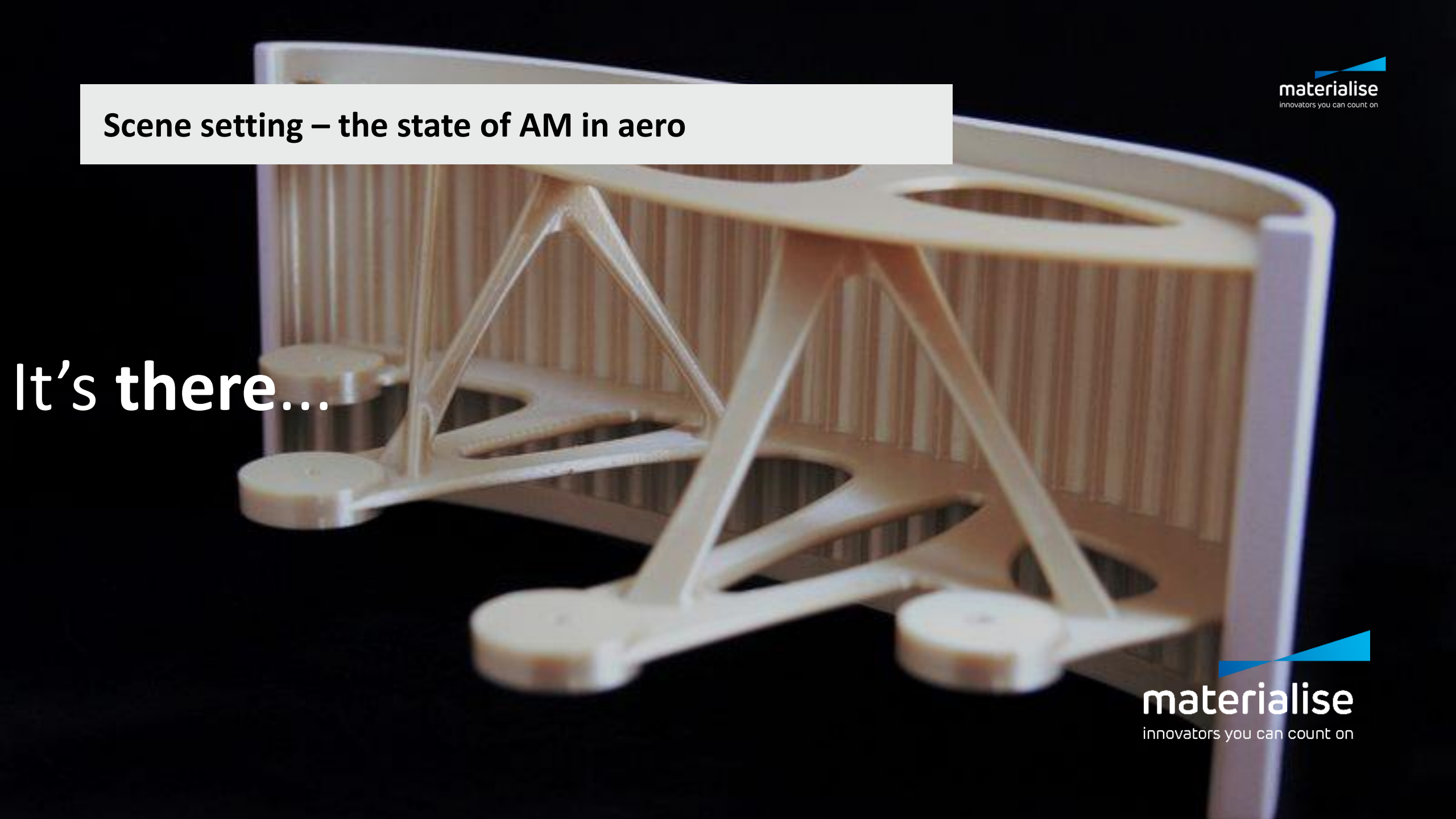
It's **growing**...



Scene setting – the state of AM in aero



It’s **there**…

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Scene setting – the state of AM in aero

… But still **a journey ahead**

Certification Memorandum Additive Manufacturing

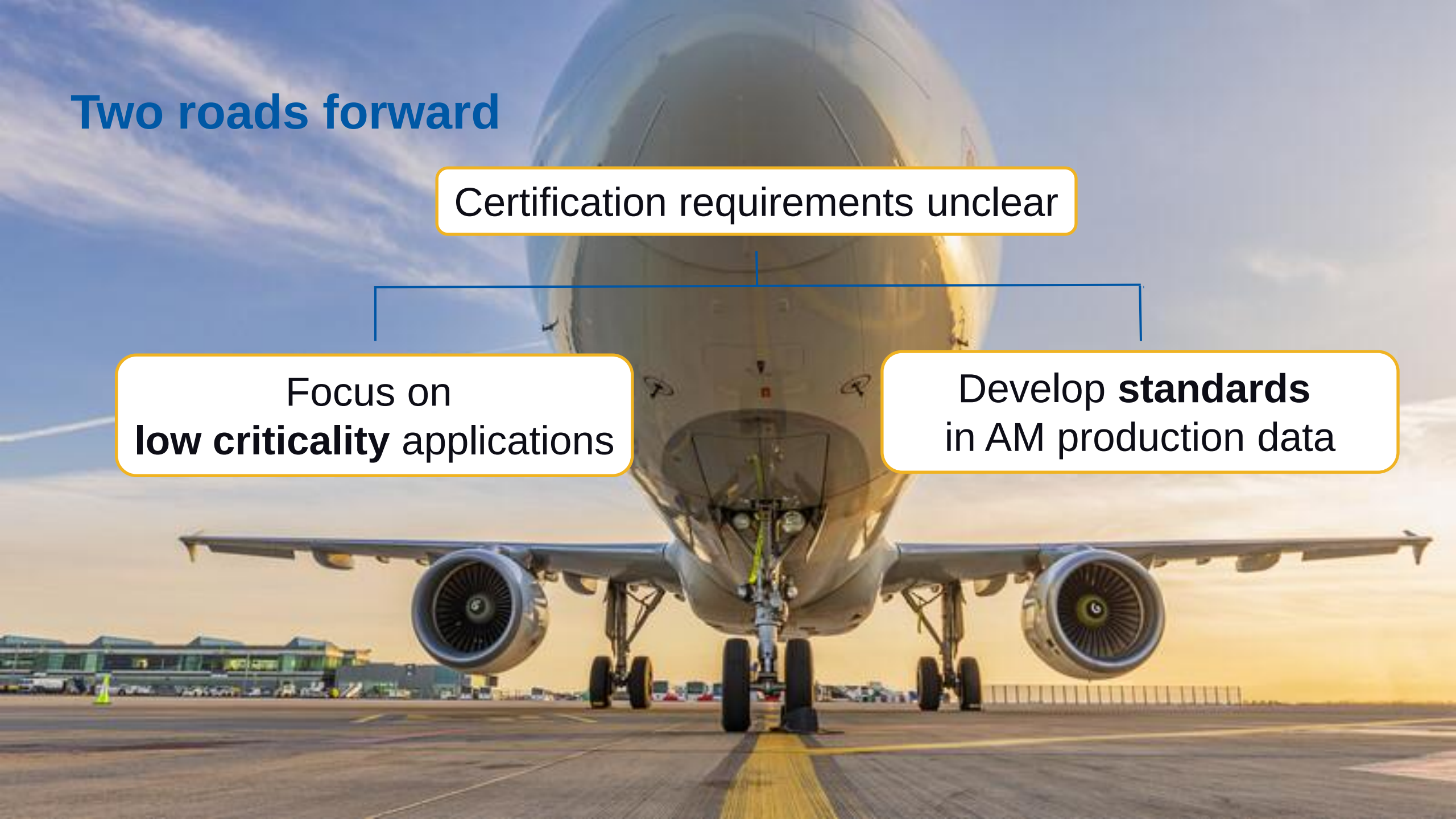
EASA CM No.: CM–S-008

…these methods can produce complex parts with ‘engineering properties’ which are highly material, process, and configuration dependent and which may generate significant variability if production is not governed by strict process control documentation. Therefore, design and production of a certifiable part will rely upon close communication between design organisations, production organisations, and material suppliers…

Addressing the qualification challenge

- EASA memorandum update in Nov. 2020 is hinting for the first time at the **distinction between low and high criticality** in the context of AM
- EASA trying to **reduce burden and LOI** on low-criticality parts; defining certification needs be **proportional to criticality**, novelty, complexity
- Make industry more **autonomous** in collaborating for these applications
- **Definition** of no/low vs high criticality yet to be developed

Two roads forward

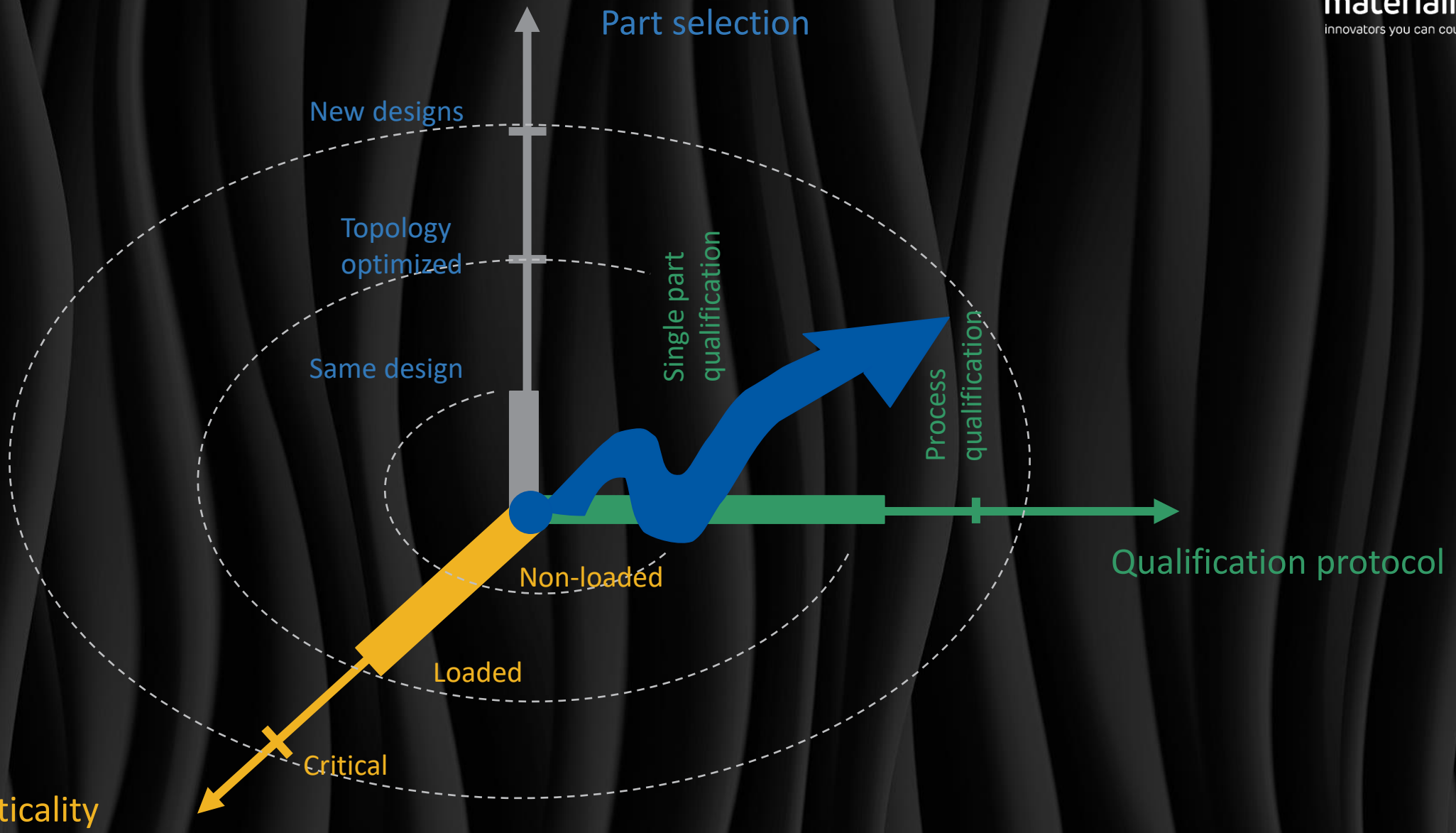


Certification requirements unclear

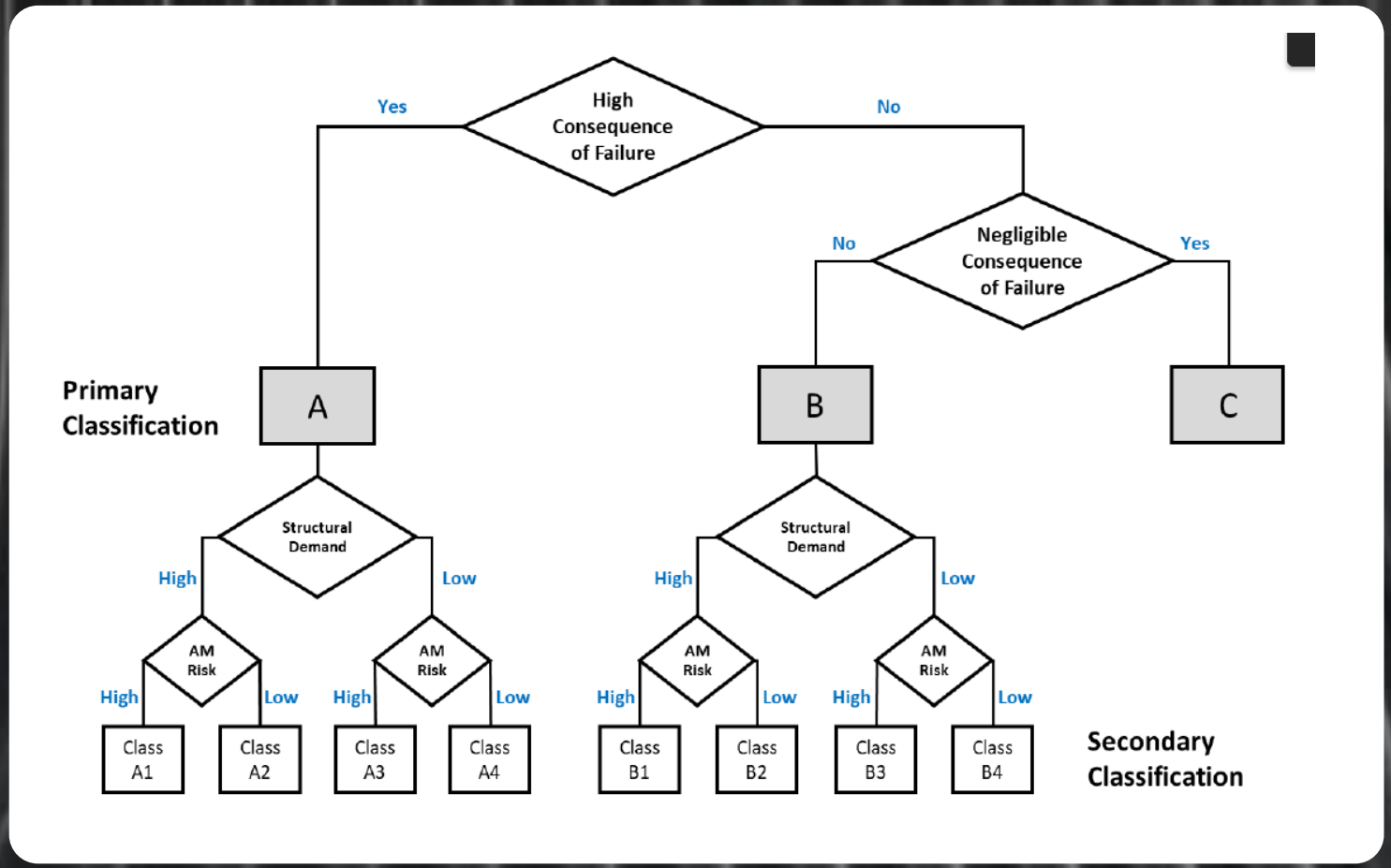
Focus on
low criticality applications

Develop **standards**
in AM production data

A step by step approach



Part classification



Focus on low criticality near term,

while evolving the landscape for longer term high(er) criticality

Manufacturing Control

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- Level of control in the part design vs level of details in the manufacturing system
- Up-front control of material and processes vs post-production checks and inspections
- **Application criticality** is always a factor

Manufacturing control is a delicate balancing act

Low criticality parts: Materialise aerospace in numbers

26,000 parts per year for the Airbus A350 ecosystem

700 part series per year across diverse aerospace customers

Over **10,000 units** in our longest-running series of recurring parts

Over **160,000** Flying parts produced

High(er) criticality parts: a slow (r)evolution

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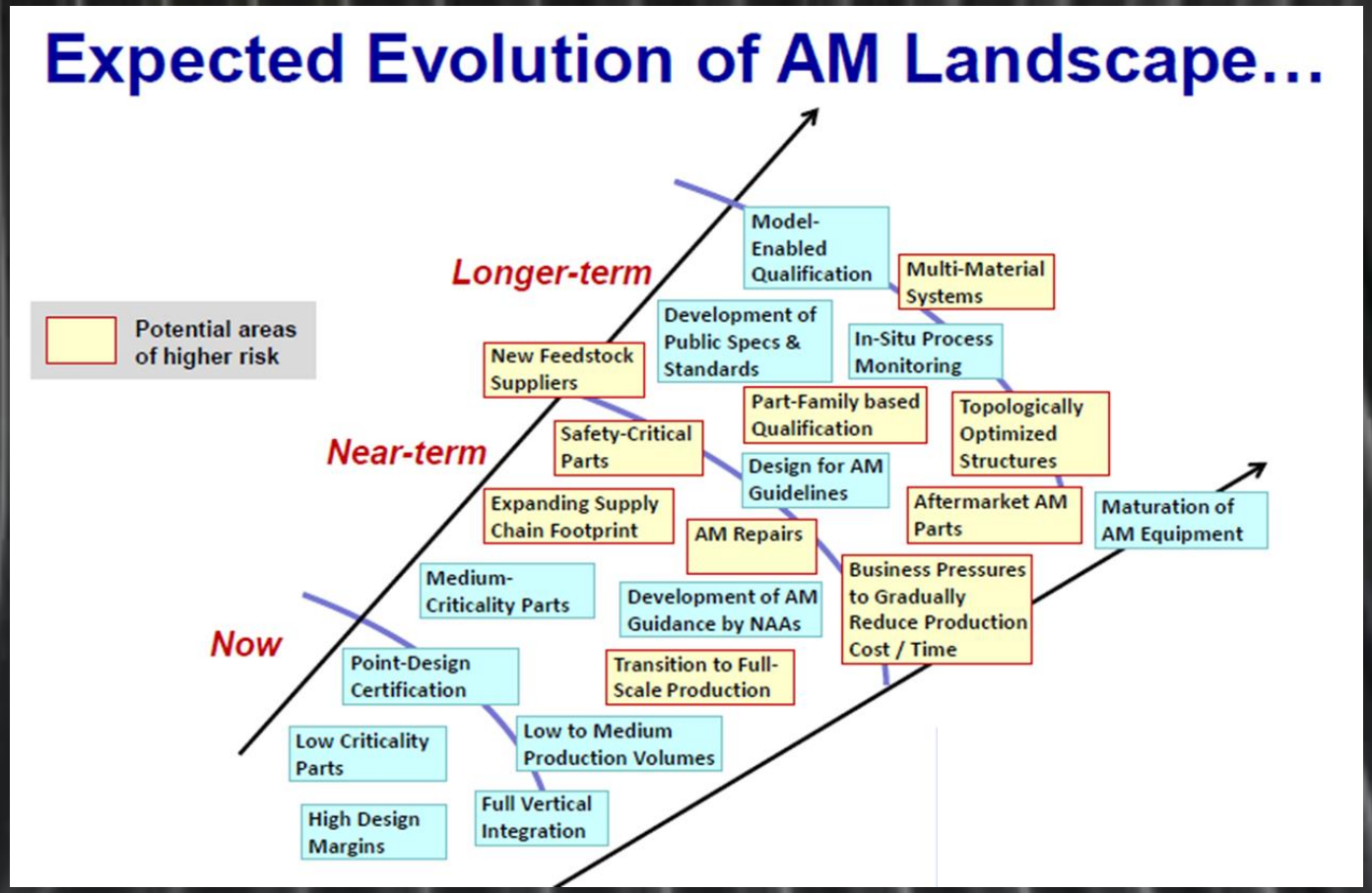


This slide was initially developed in 2017 …

most elements are still relevant today

Scene setting – AM specific attributes to address

- Characterization and role of inherent (and rogue) material anomalies/defects
- Anisotropy
- Location-specific properties
- Residual stresses
- High process sensitivity / large number of controlling parameters
- Effects of post-processing (HIP, heat treatment, surface improvements, …)
- Material-specific NDI considerations
- Effect of surface conditions
- Susceptibility to environmental effects
- ...

Each individual category has been encountered in other material systems

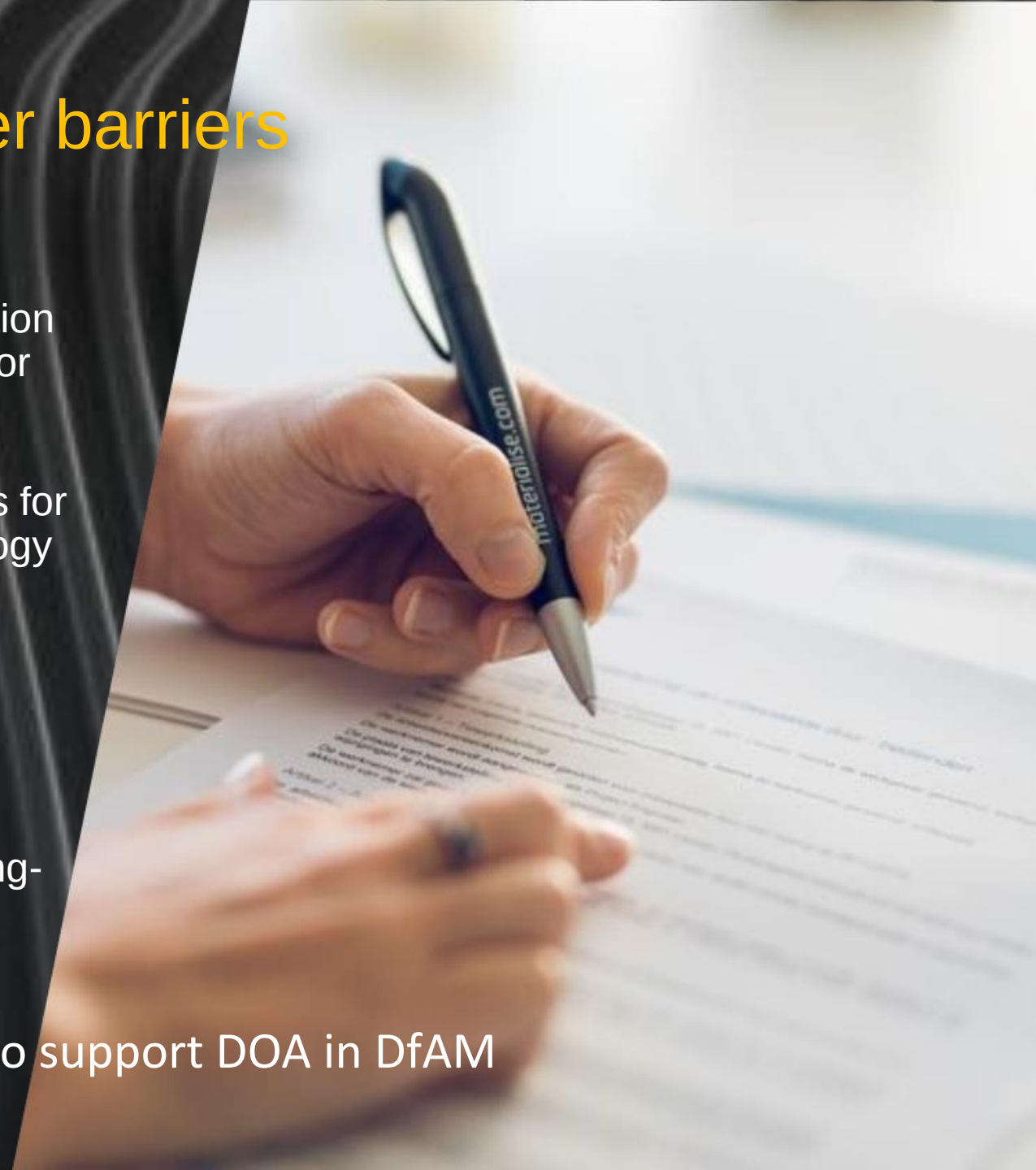
Unique nature of AM: ***all of these categories may apply***

Minimum Tensile strength is not sufficient for higher criticality parts

Materialise commitment to lower barriers

- Materialise has a role as an EASA 21.G Production Organization in lowering the certification barrier for new AM-suitable parts
- Experience in supporting the certification process for new parts, successfully qualifying a new technology with Airbus
- We offer co-creation of allowables to support qualification efforts
- We support customers in defining design values, based on the material allowables obtained for long-term process control data

GOAL: build a comprehensive database to support DOA in DfAM



Scene setting: Traditional part design approach

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Authority

DOA

- *standards/norms*
- *databases*
- *best practises*
- *handbooks*
- *…*

POA

Materialise data sharing approach

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- *standards/norms*
- *databases*
- *best practises*
- *handbooks*
- *…*

Data sharing

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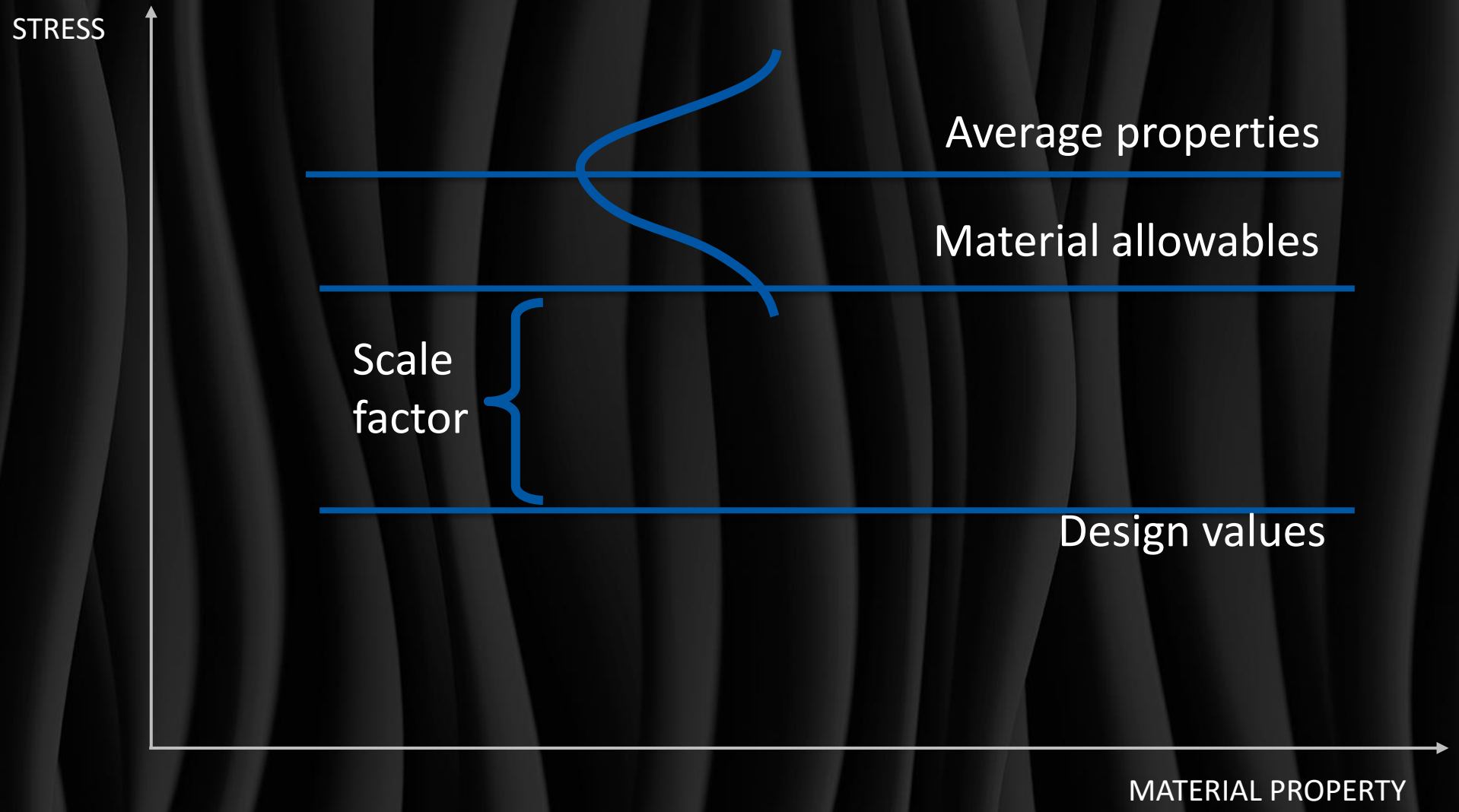

Data sharing

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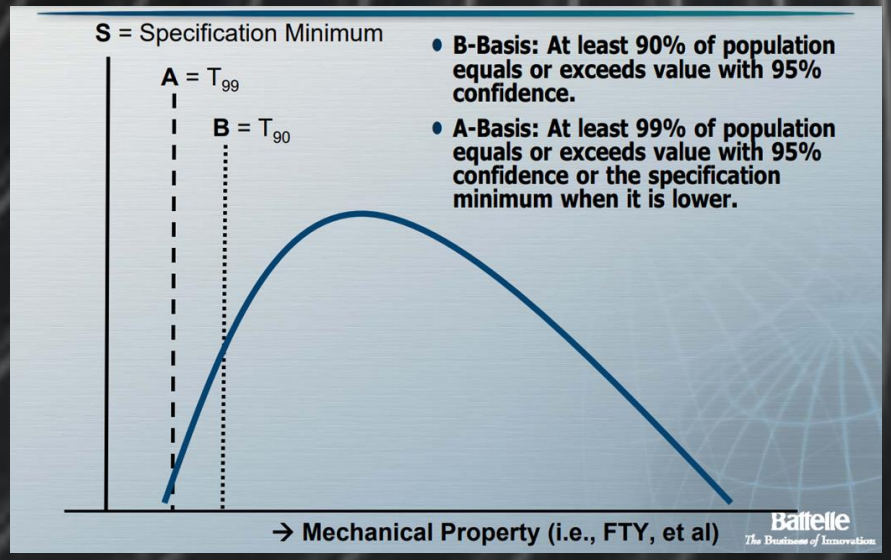
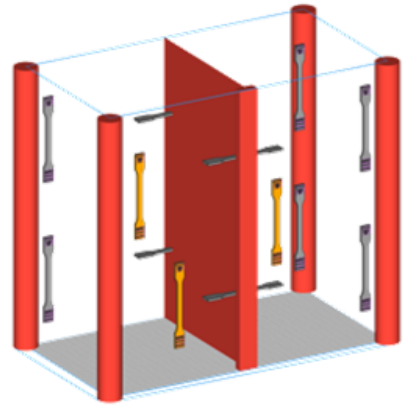
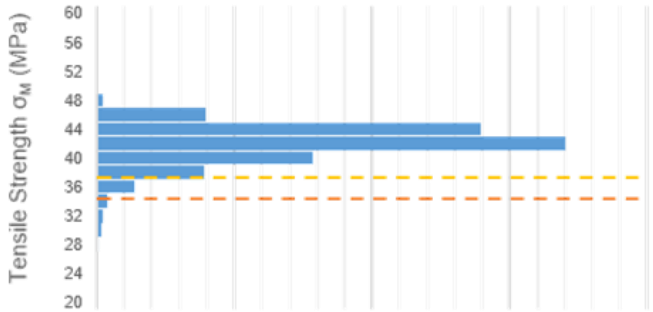
- *Process* *PCD RO PA2241*
- *Material* *PA2241FR*
- *Machine Type* *EOS P760 | P770*
- *Test Method* *ISO 527-2/A1*

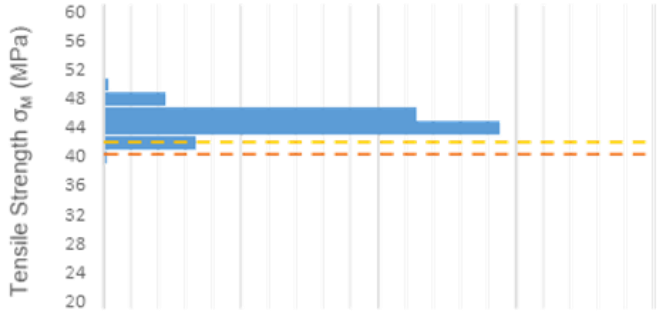


MECHANICAL PROPERTIES

Production Period	11/2019	to	10/2021
# Measurements	1966 (ZX) &	635 (XY)	
# Production Builds	232		
# Raw Material Batches	8		
# Mixed Material Batches	128		







Tensile Strength σ_M	**(ZX)**		
A-basis	34,7 MPa	avg	41,0 MPa
B-basis	37,5 MPa	median	41,3 MPa
		stdev	2,7 MPa

	(XY)		
A-basis	40,3 MPa	avg	43,8 MPa
B-basis	41,9 MPa	median	43,8 MPa
		stdev	1,5 MPa

Data sharing

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VERIFICATION
of endproduct

VALIDATION
of process

IQ Installation Qualification

OQ Operational Qualification

PQ Performance Qualification

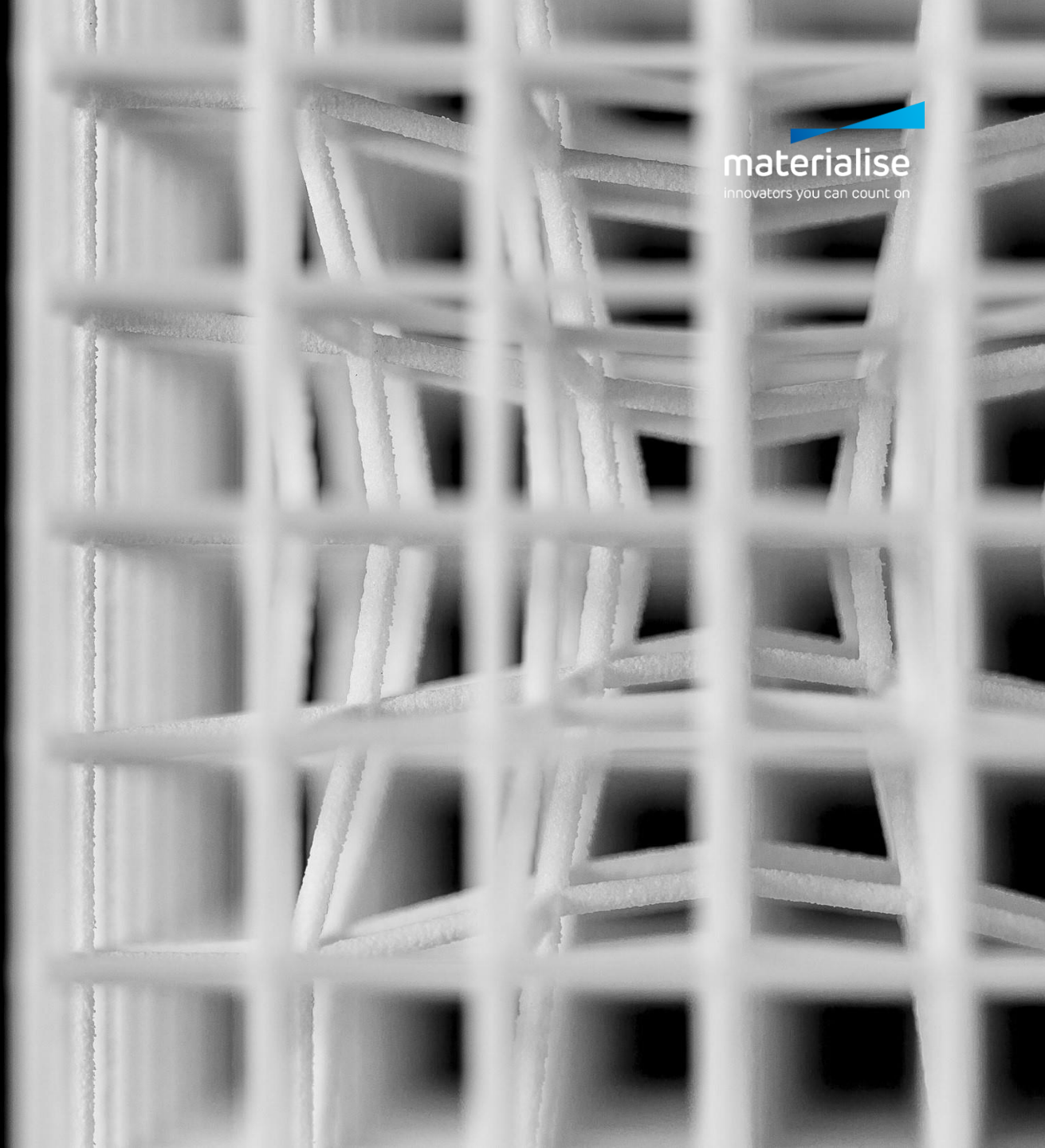
Start from desired output:

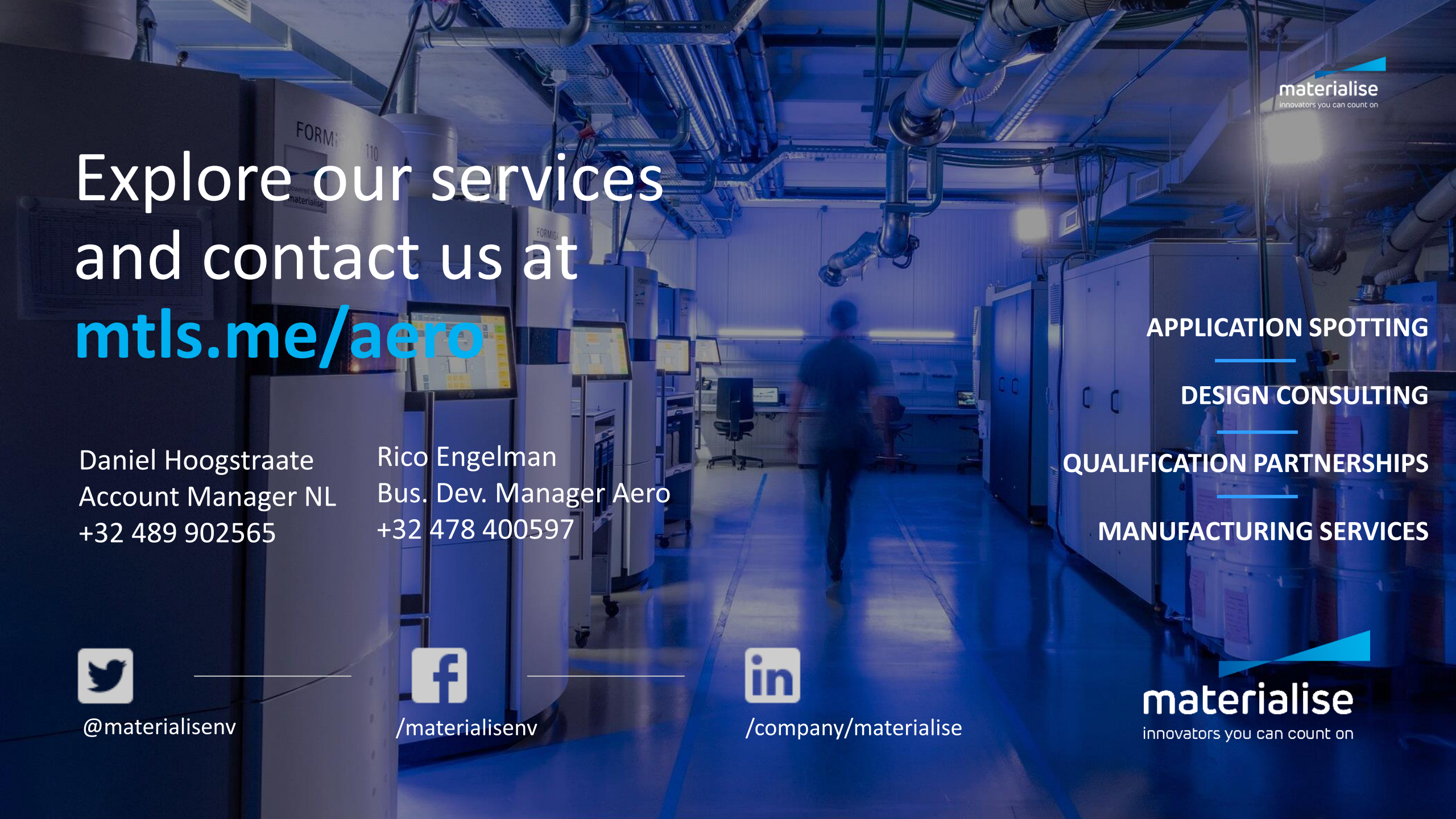
Predetermined Quality Characteristics for PROCESS validation

Questions

Design for Additive Manufacturing (DfAM)

Wouter Maleux





Explore our services and contact us at **mtls.me/aero**

Daniel Hoogstraate
Account Manager NL
+32 489 902565

Rico Engelman
Bus. Dev. Manager Aero
+32 478 400597

APPLICATION SPOTTING

DESIGN CONSULTING

QUALIFICATION PARTNERSHIPS

MANUFACTURING SERVICES

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