Parts for the F-35 – From CNC to Additive

FORCE TECHNOLOGY

Motivation: Increase process competitiveness

Save materials. Save time. Save money.

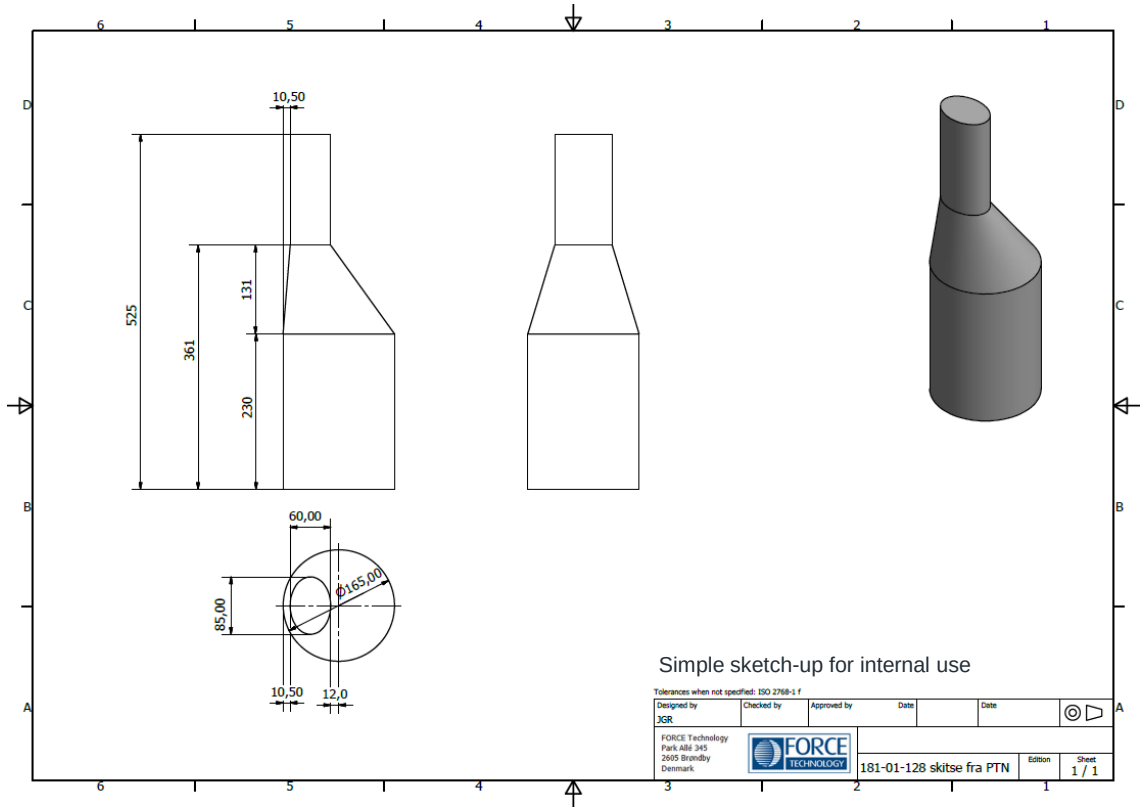
Motivation

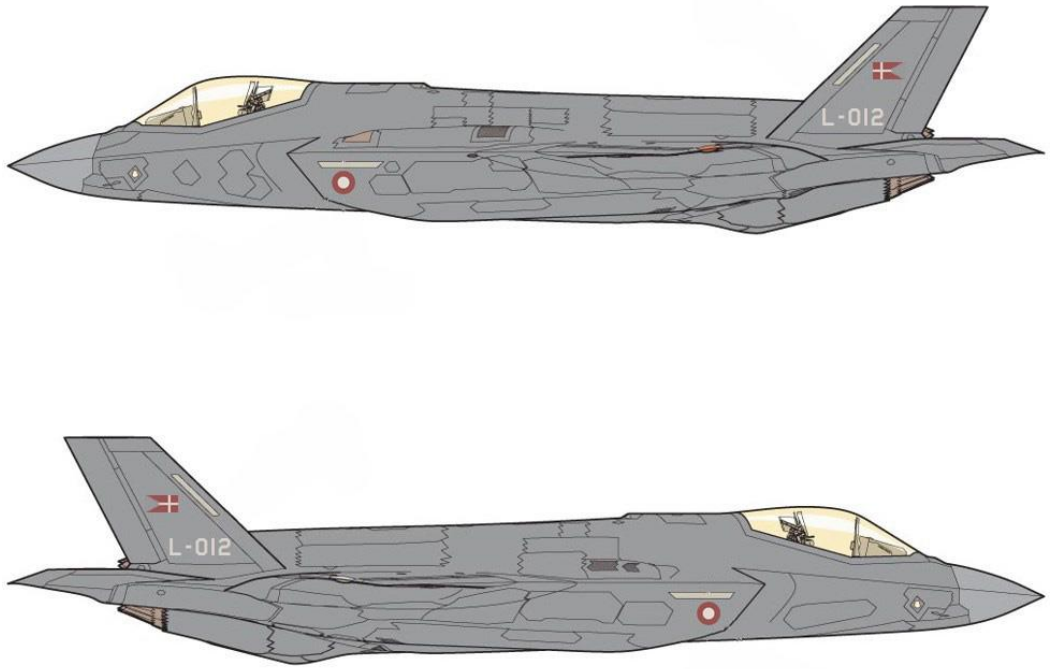
AM is saving time and money. That is why.

- Cost reductions upto 90 %
- Processing time reductions of upto 95 %
- Materials savings
- Freedom of design
- New surfaces and materials possible
- Refurbishing made possible
- Re-manufacturing enabled

Building ”a component” for the F-35 Joint Strike Fighter

Actual part and application is confidential

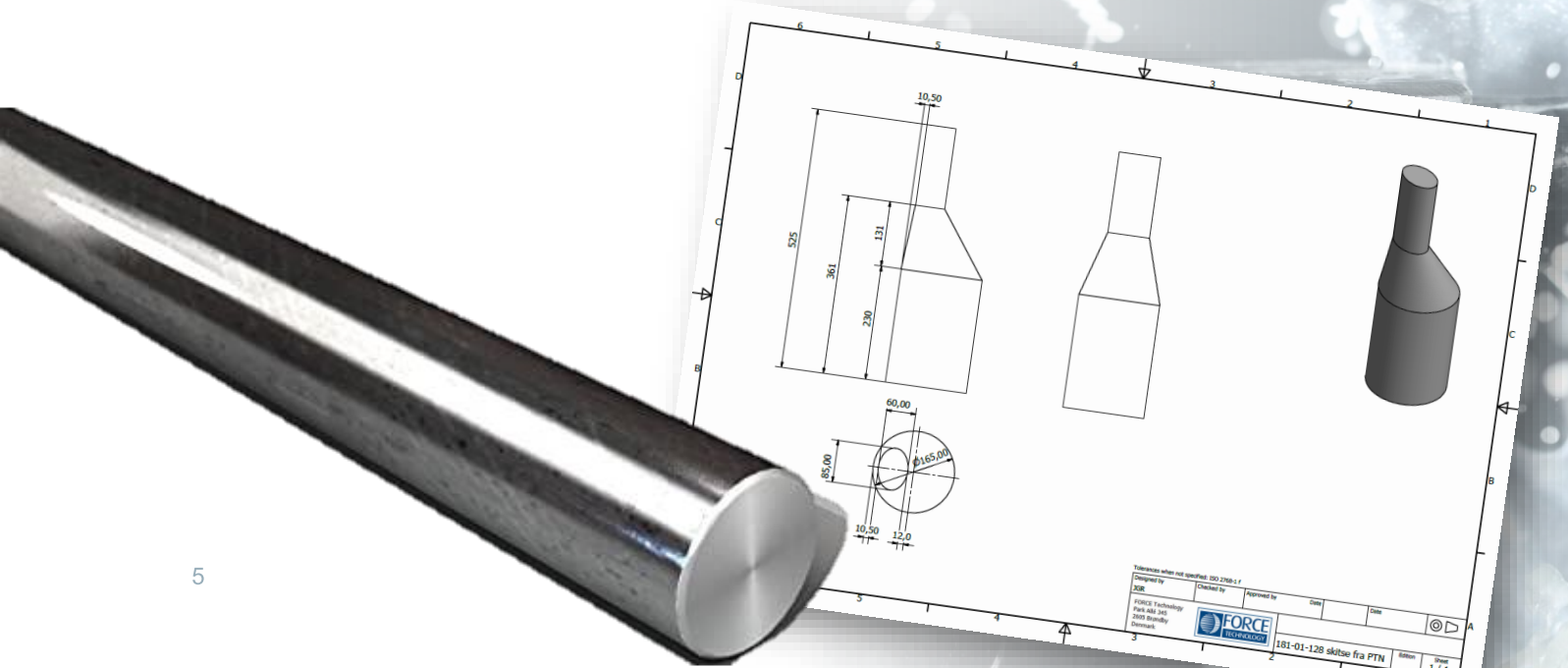




Present day state of the art

CNC Machining – Baseline

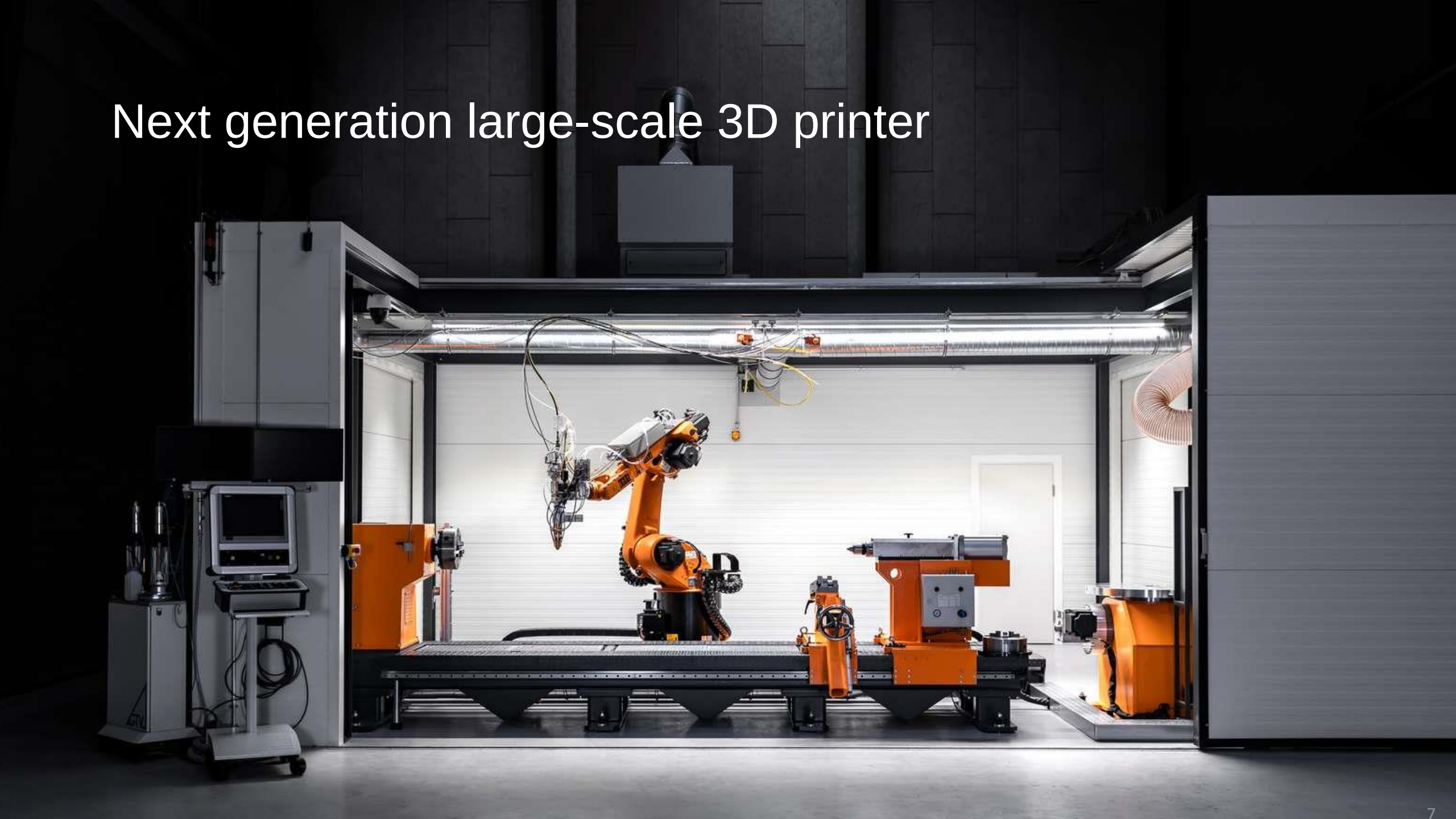
- 15-5PH steel (app. 2x the price of AISI 316L)
- 219 kg rod base
- Upto 120 hrs CNC milling time



Technique – The ”How”

Large-scale 3D printing – Direct Laser Deposition

Next generation large-scale 3D printer

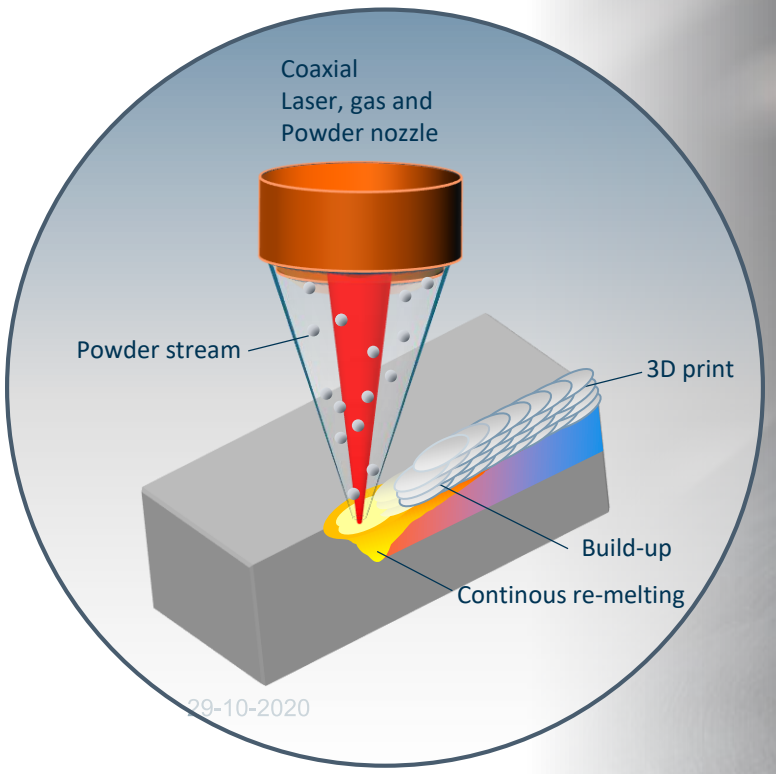


Directed Energy Deposition

Technology keywords

- Direct (blown) powder
- Laser energy source
- Shielding gas inherent
- Industrial robot control

- Large-scale
- High-deposition rates



Free-form 3D printing

High-temp super-alloy for aerospace – Making a shift from CNC-machined to 3D printed

Machined
219 kg
120 hrs

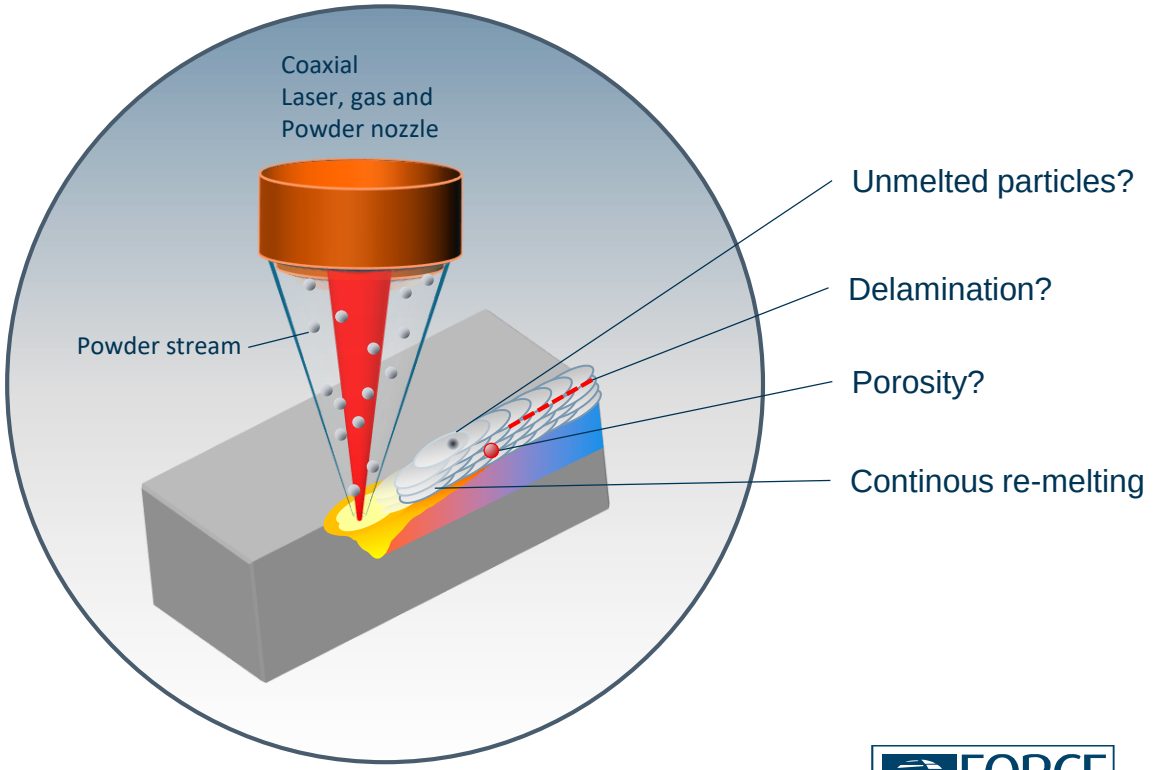
3D printed
9 kg
4.5 hrs

3D printed components – Are they any good?

Mechanical test results

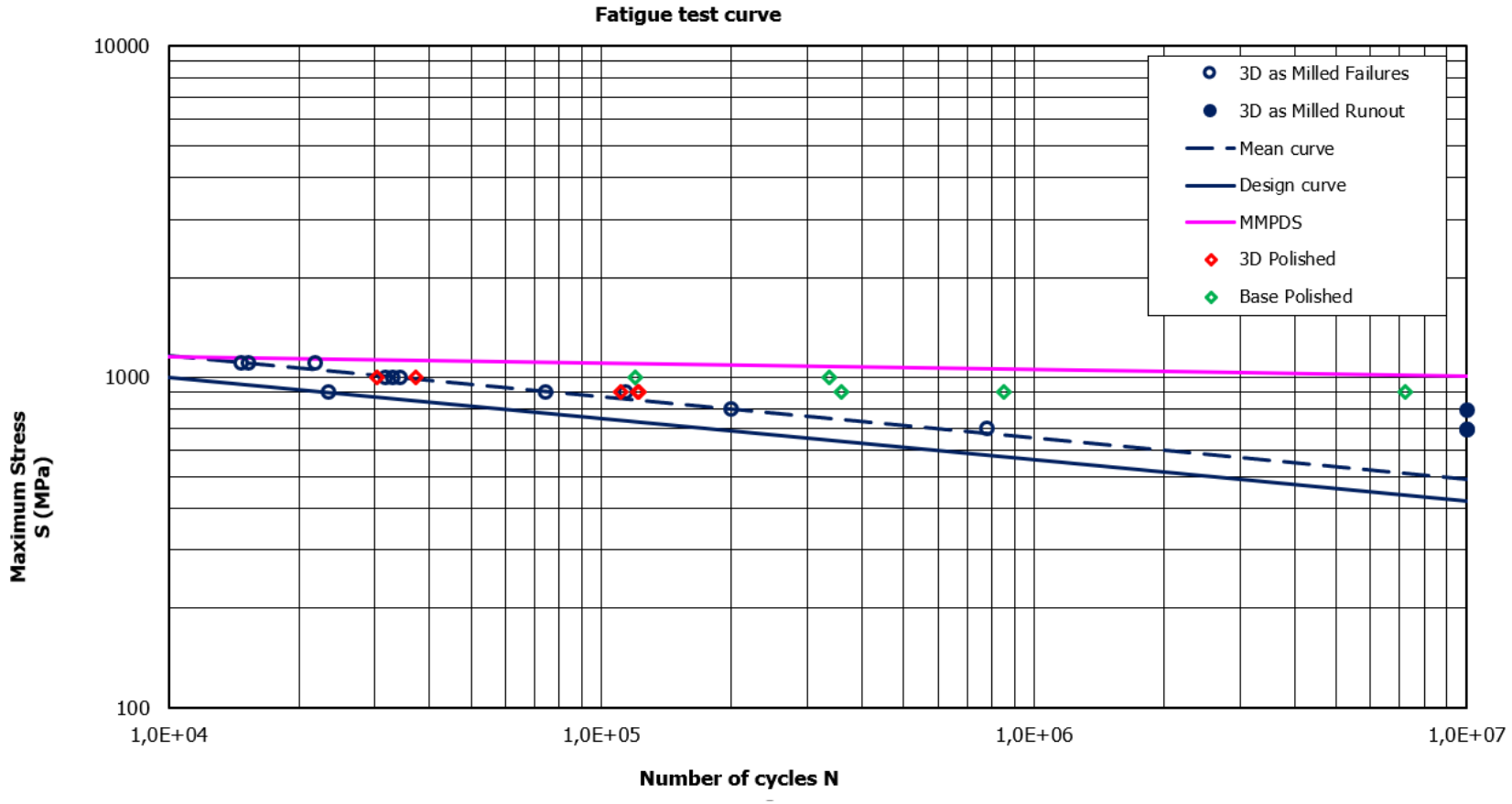
What may happen during 3D printing?

Potential failure mechanisms and initiators



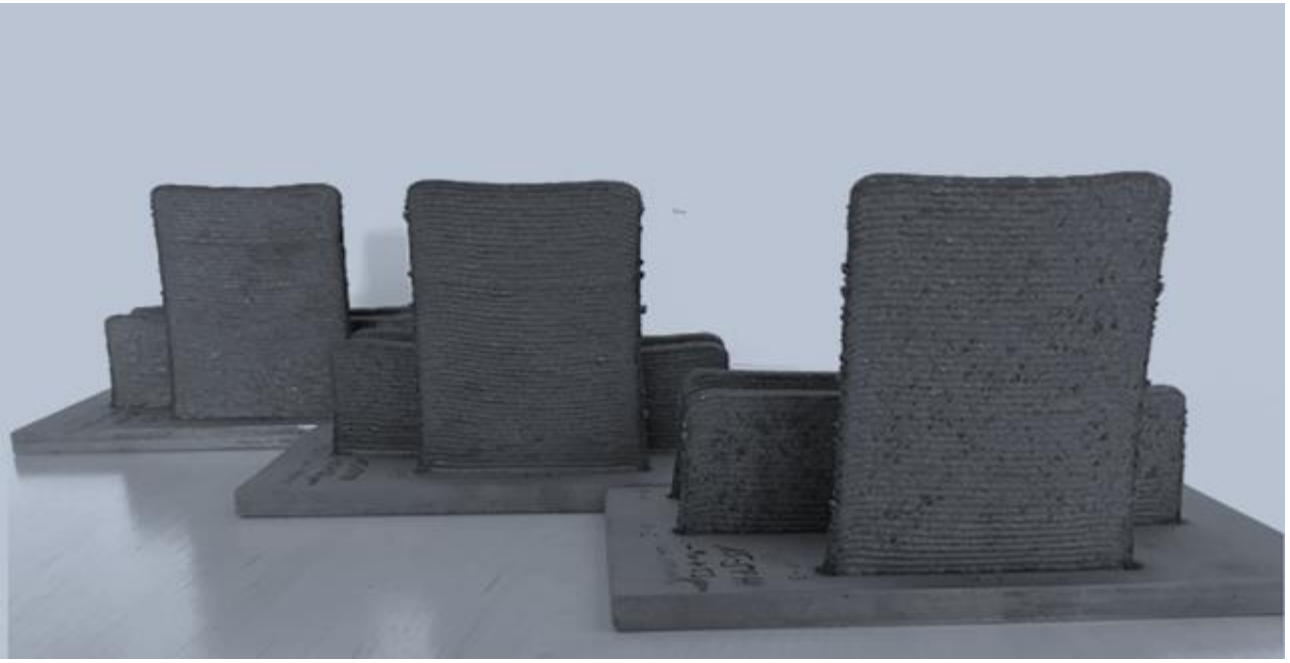
Fatigue life

Polished vs. milled samples



Powder particle influence

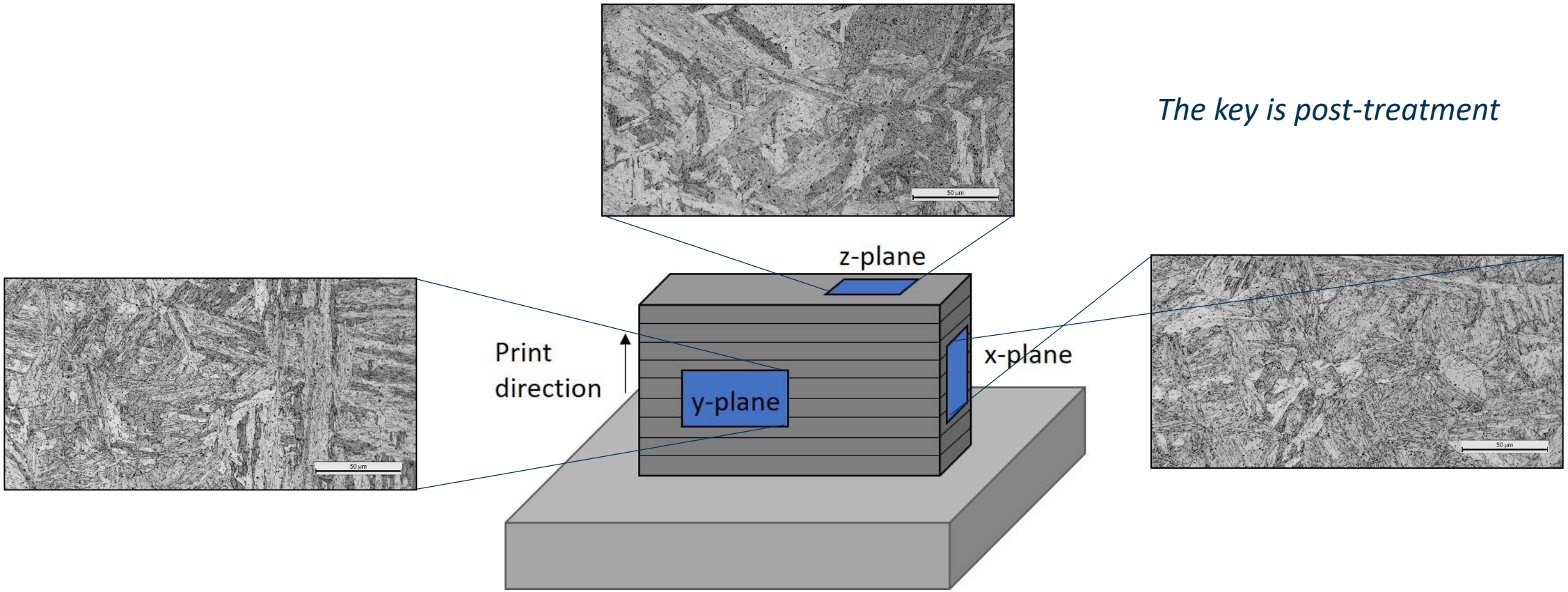
Little impact on build-rate and DE. Some impact on spatter and seam width



PSD [µm]	Spatter	Seam width [mm]	Build rate [mm]	Deposition Efficiency (DE)
53 < ø < 90	Yes	4,0	1,0 28,7 g/min	77%
22 < ø < 53	No	4,5	1,0 30,4 g/min	85%
15 < ø < 45	No	4,8	1,0 30,9 g/min	86%

Structural dependance on print direction

… it does not matter much



The key is post-treatment

Service conditions test at elevated temperature

Hot tensile test at 600°C

Temp.	Test vs. Spec.	Tensile [MPa]	Yield [MPa]	Elongation [%]
20°C	Obtained	**1133**	**1077**	**14.8**
	MMDPS	1067	1000	12.0
600°C	Obtained	**534**	**485**	**10.3**
	MMDPS	?	?	?
Reduction (20-600°):		53 %	55 %	30 %

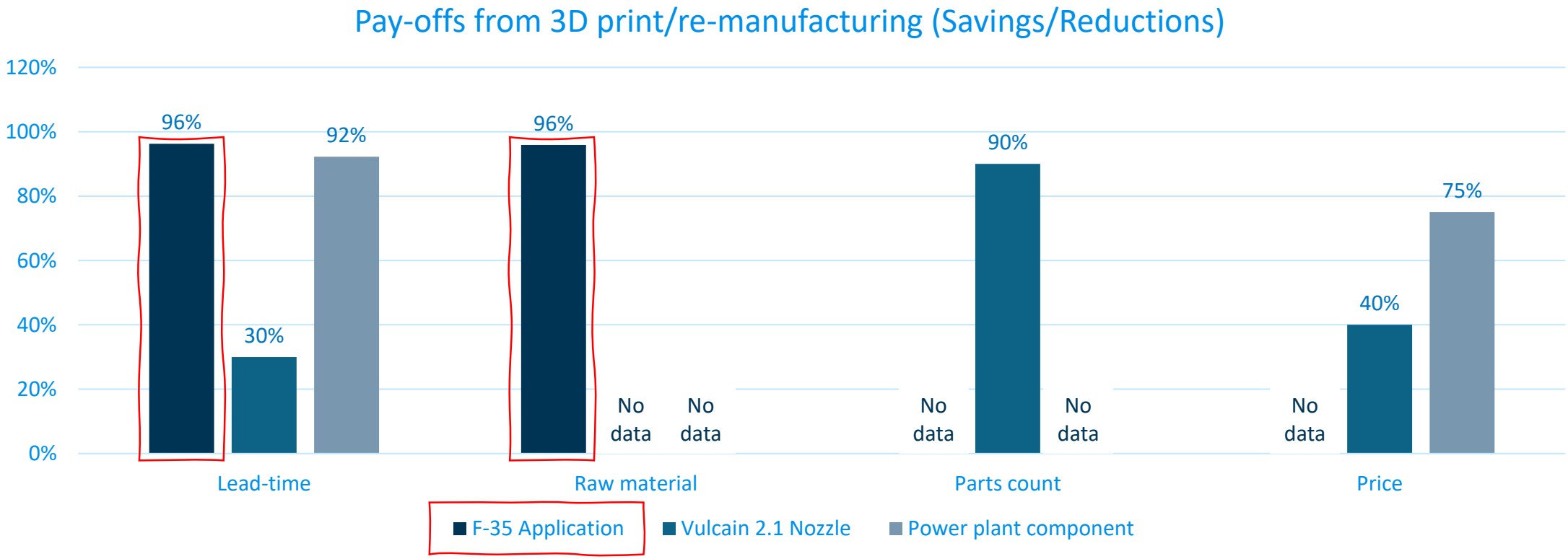
Litterature study indicates:
A drop of 40-60 % is to be expected

Economical benefits – Does 3D printing pay off?

Calculated examples

Does Large-Scale 3D print pay off?

Actual examples (FORCE Technology)



Summary – And the way ahead…

- 3D printing in metals is now possible
- Think outside of the box – or inside a much bigger box…
- Repair, refurbish and re-use. It is green and it is smart.
- Save time and materials (upto 95 %)
- Save on cost (upto 90 %)
- Quality requirements are achieveable

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