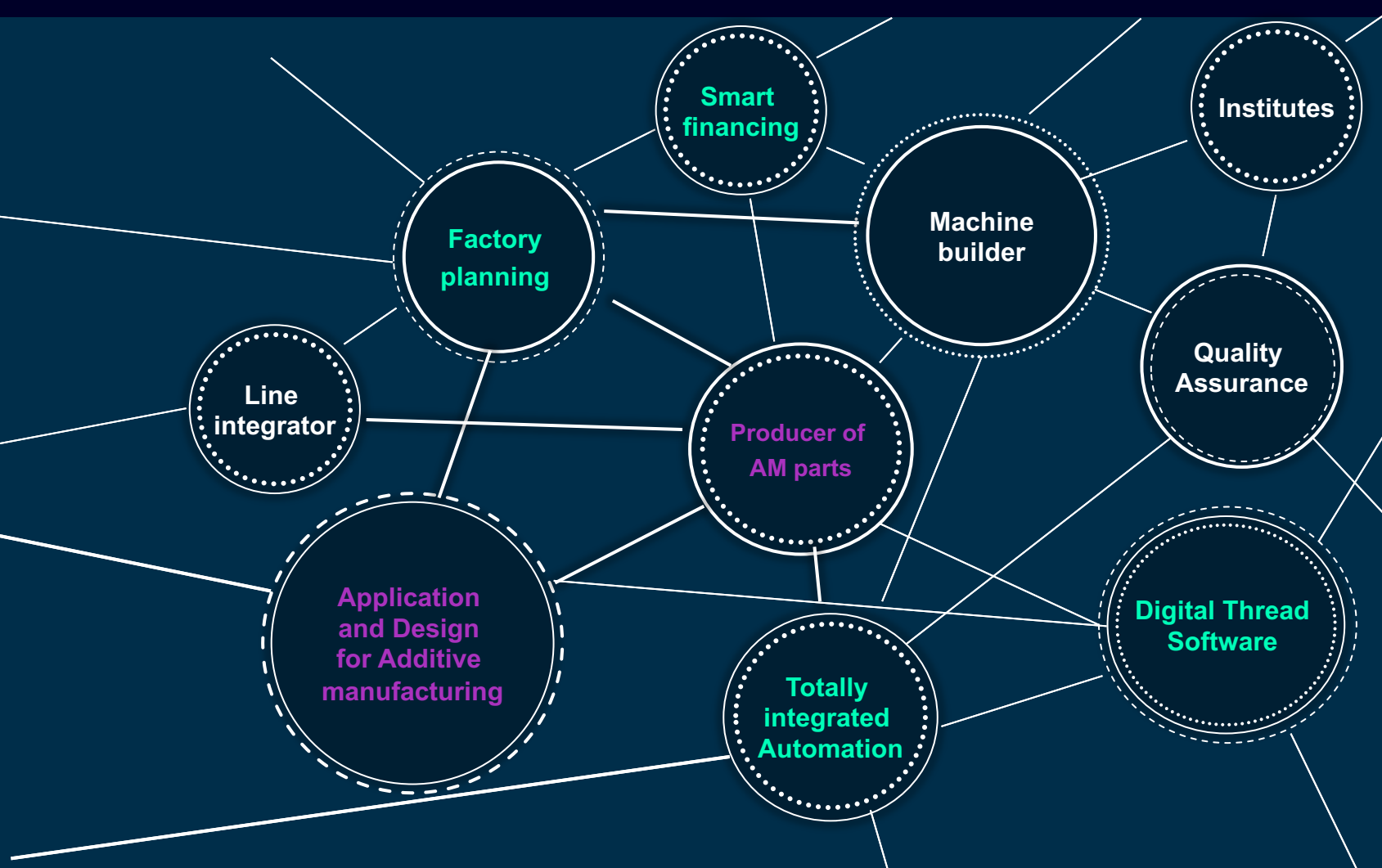


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Repair to Improve – an industrial part upgrade use case for more sustainability

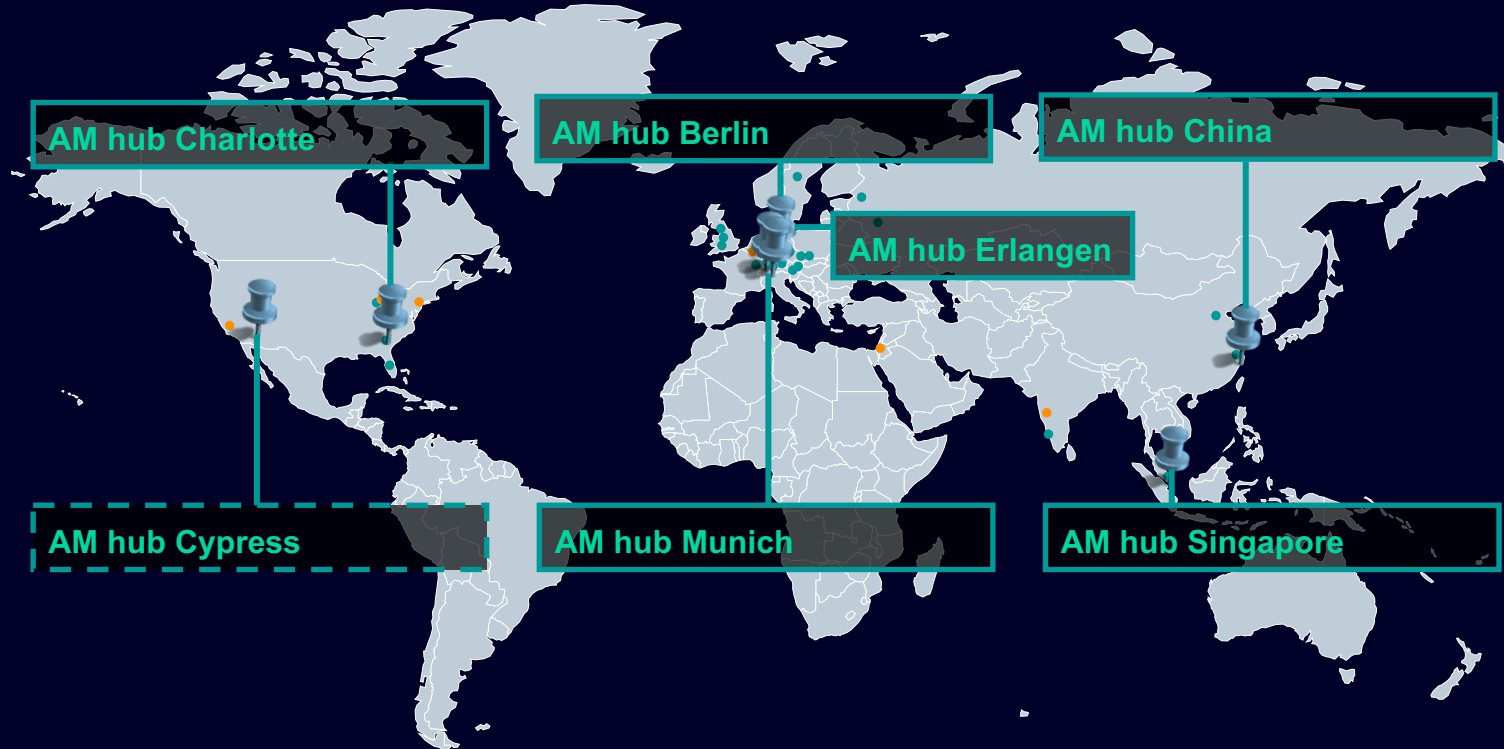
AMTC 2021 | October 13, 2021 | Markus Seibold (Siemens Energy) , Karsten Heuser (Siemens Digital Industries)

The power of eco-system development to industrialize Additive Manufacturing



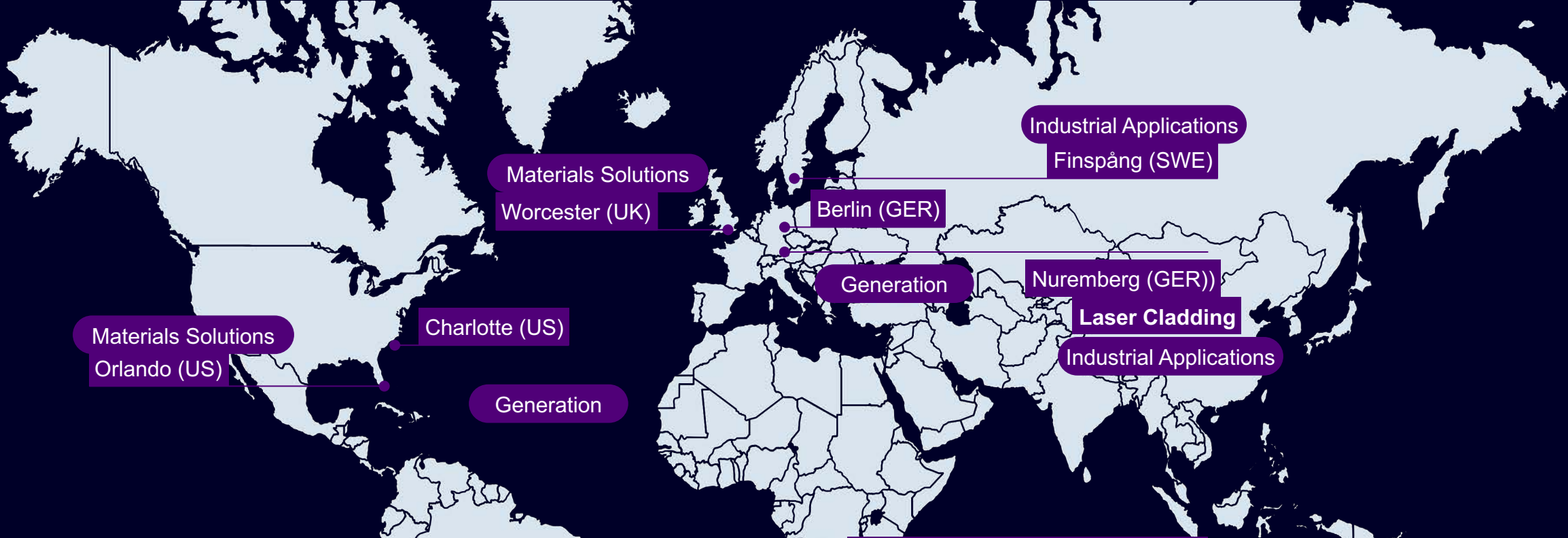
- ▶ Understand **business and application driven decision-making** paths
- ▶ **Complementing capabilities** of partner **reduces time to market** and efforts for each partner
- ▶ Joint and open innovation eco-system with **better results and faster learning cycle**
- ▶ **Roles need to be clarified** to guarantee trust on all levels

Siemens AG's global AM footprint consists of 7 hubs, strategically placed at major AM ecosystems



AM hubs as collaborative platform for Siemens to engage with our partner on a cross-unit basis in co-creating industrial AM solutions to create, make and use additive applications at scale

Siemens Energy's global Additive Manufacturing footprint



by FY21
+100 components
Qualified and growing

about
200 people
dedicated to AM

more than
50 PBF printers
with factory space
for up to 100 printers





Gas Turbine Blade after 30,000 hours of operation



Requirements for Additive Manufacturing to give this part a new life

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Operate in harshest environment

- Extreme temperatures 1200+°C
- Mega centrifugal loading
- High transient load

Quality criteria are very high

- Highest tolerancing
- Single crystal

Function essential to stabilize turbine operation

Tight gap between blade and ring segment ensures sustained output

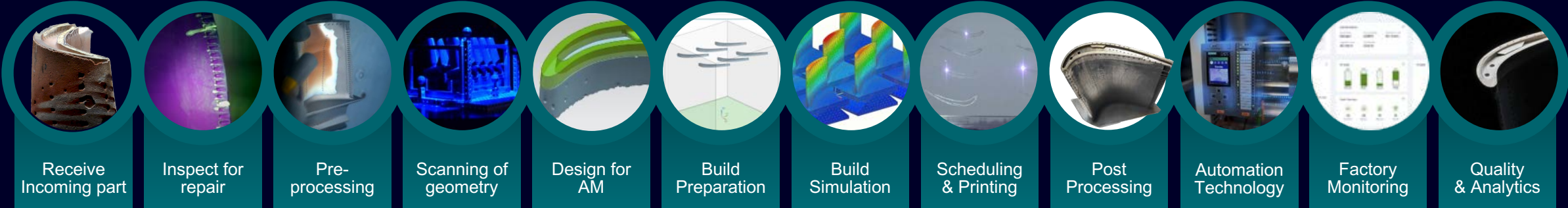


50%
Oxidation at tip

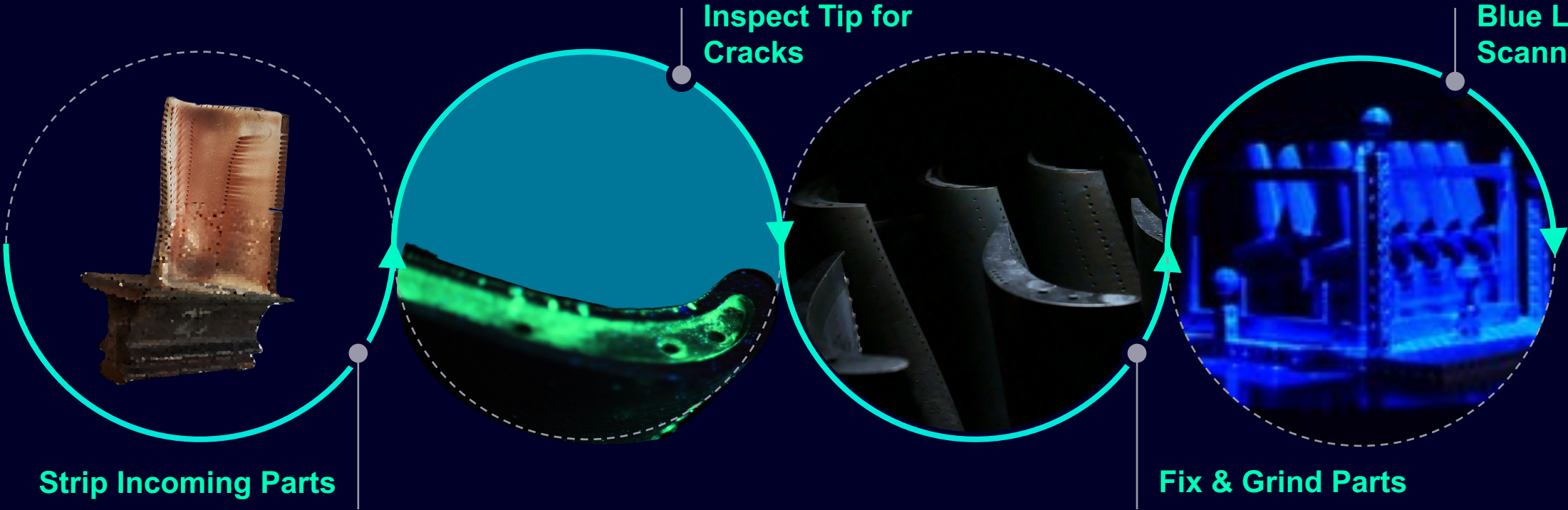
End-to-end workflow from inspection to printing requires a seamlessly integrated digital thread



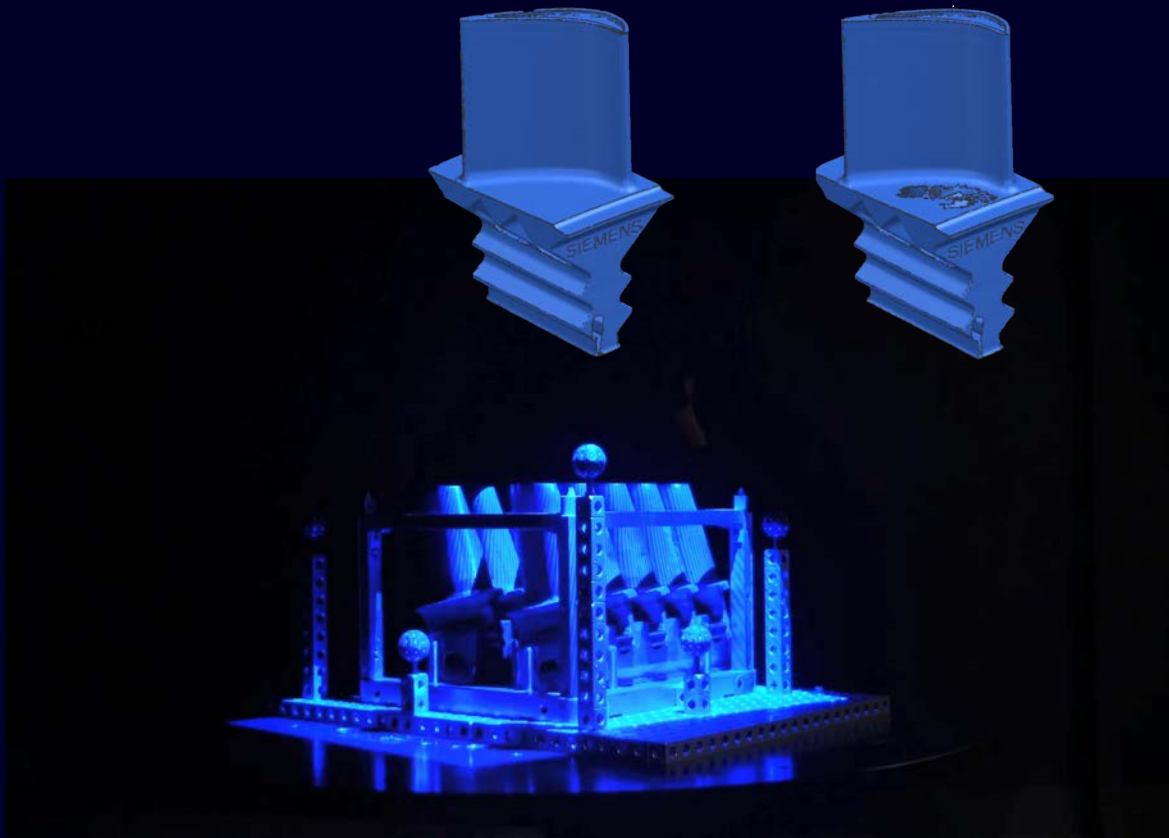
Holistic digital thread for metal power bed fusion repair workflow



First we need to understand the part's condition and scan the data

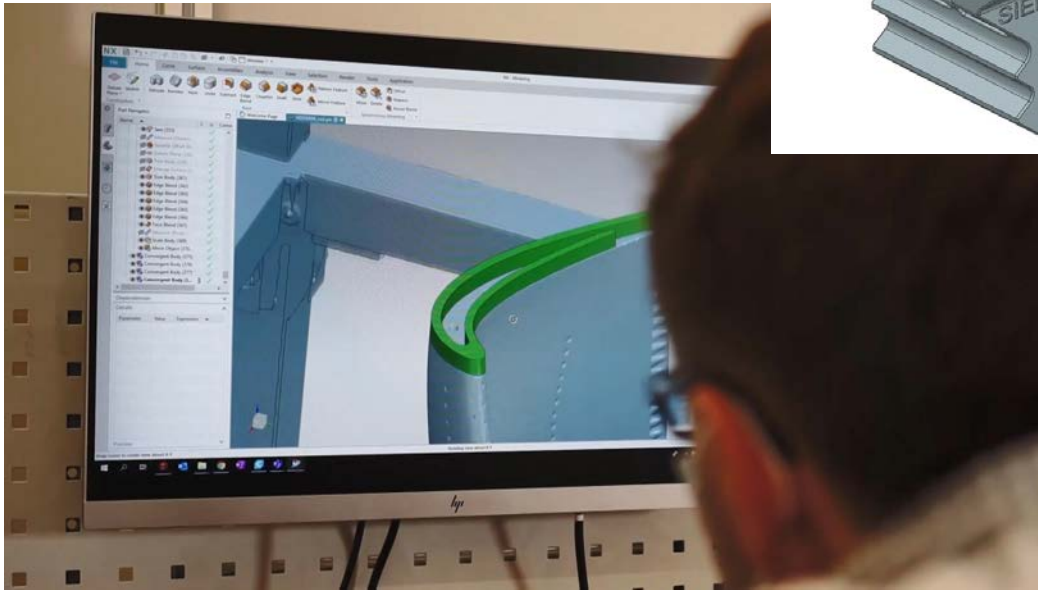
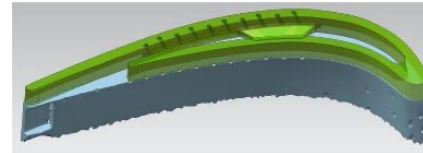
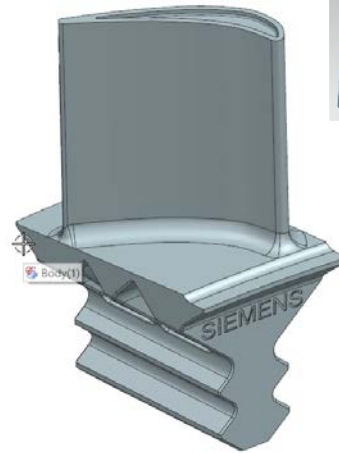


Transforming the repair part into a digital twin for further design optimization by scanning



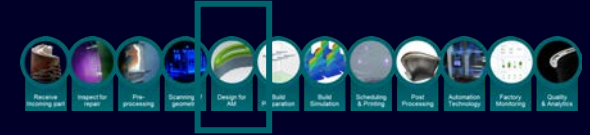
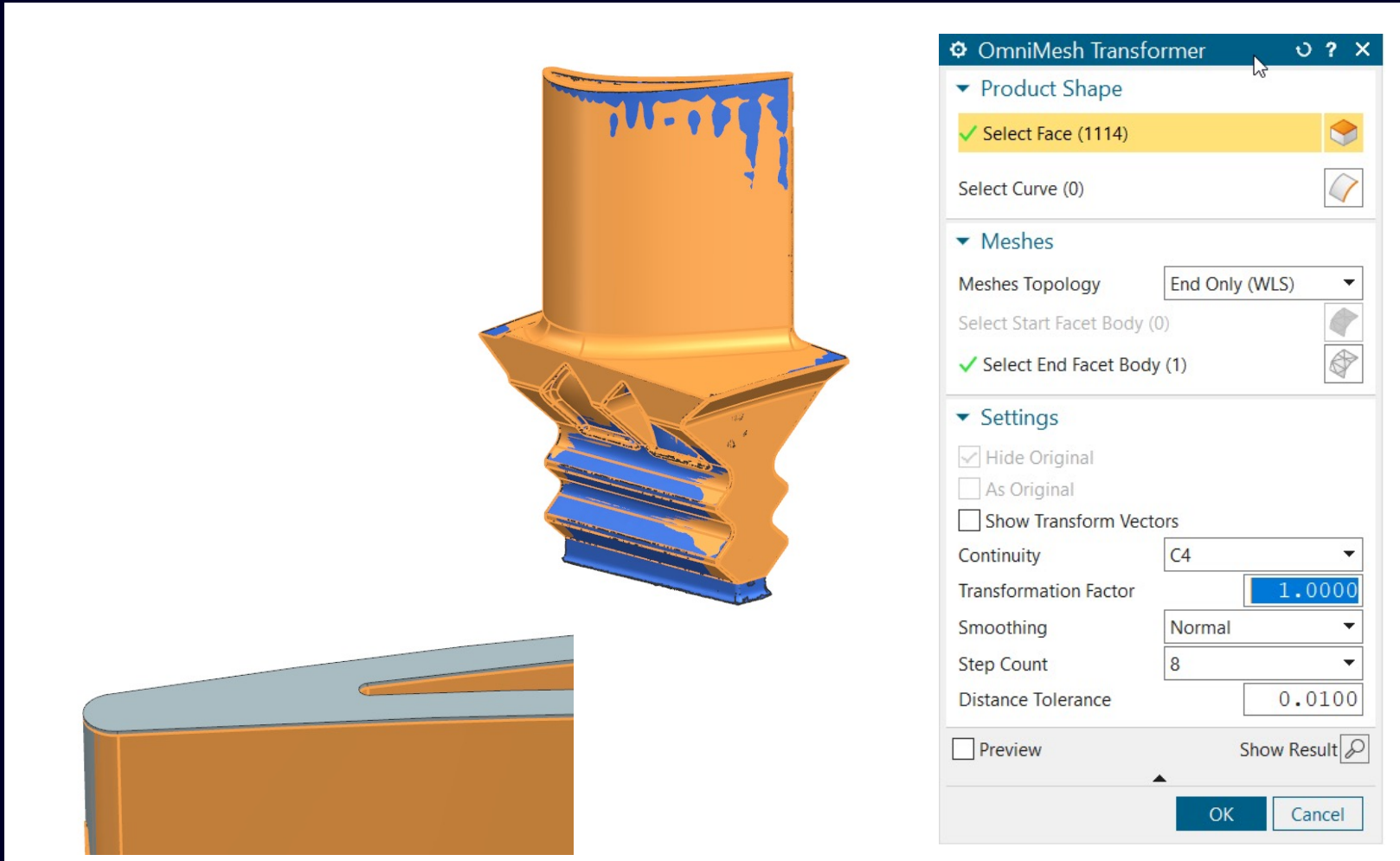
- Blue light scanning was used in this case
- Results are saved as STL files

Decomposition of part and tip upgrade by design exploration and simulation on resulting flow behavior



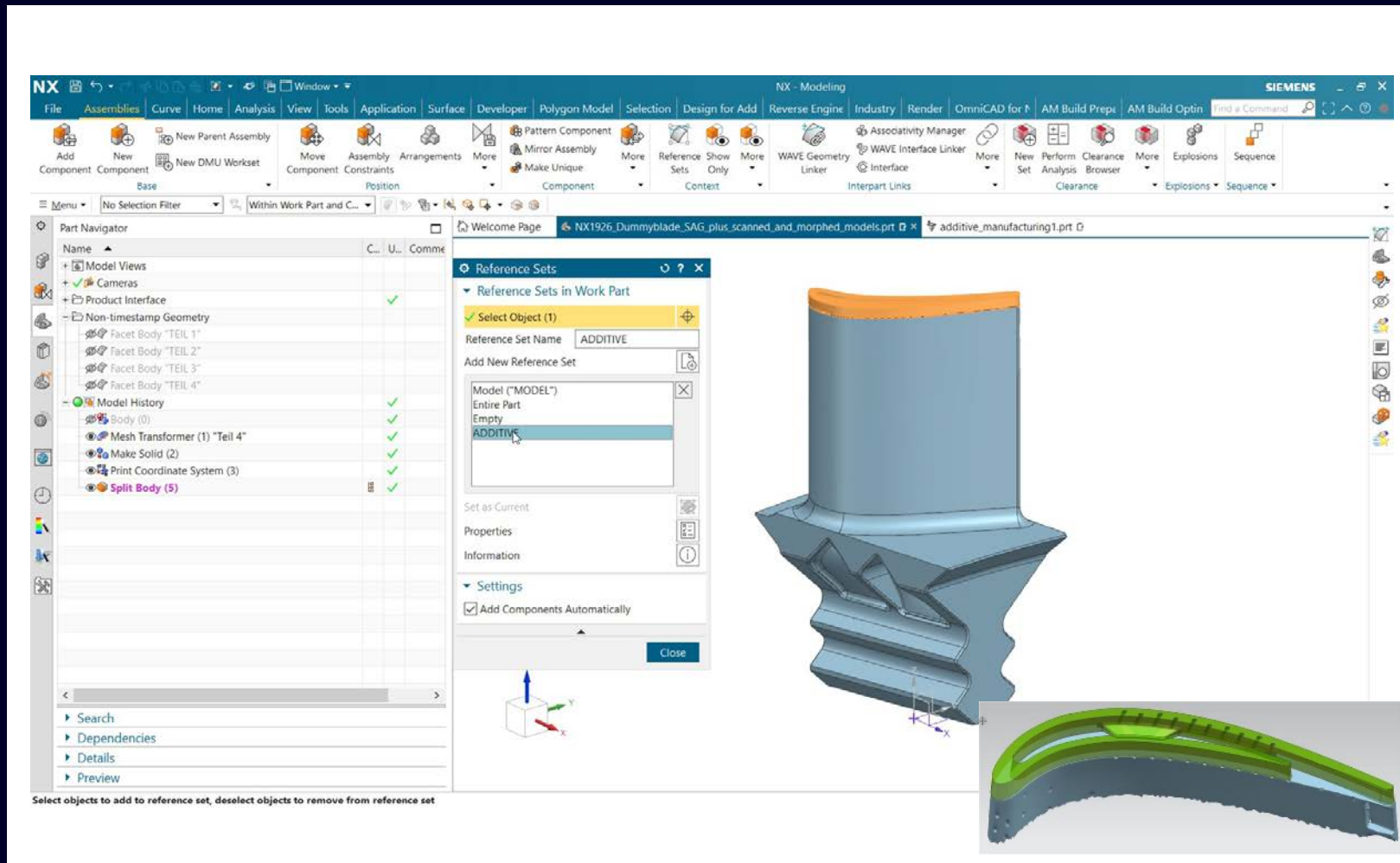
- Create various design alternatives by adding or modifying features
- Use Simulation to compare them and find the one with the best performance
- Optionally use HEEDS for a multi-objective optimization

Morph design changes according to scan of each part and adjust towards individualized repair of part



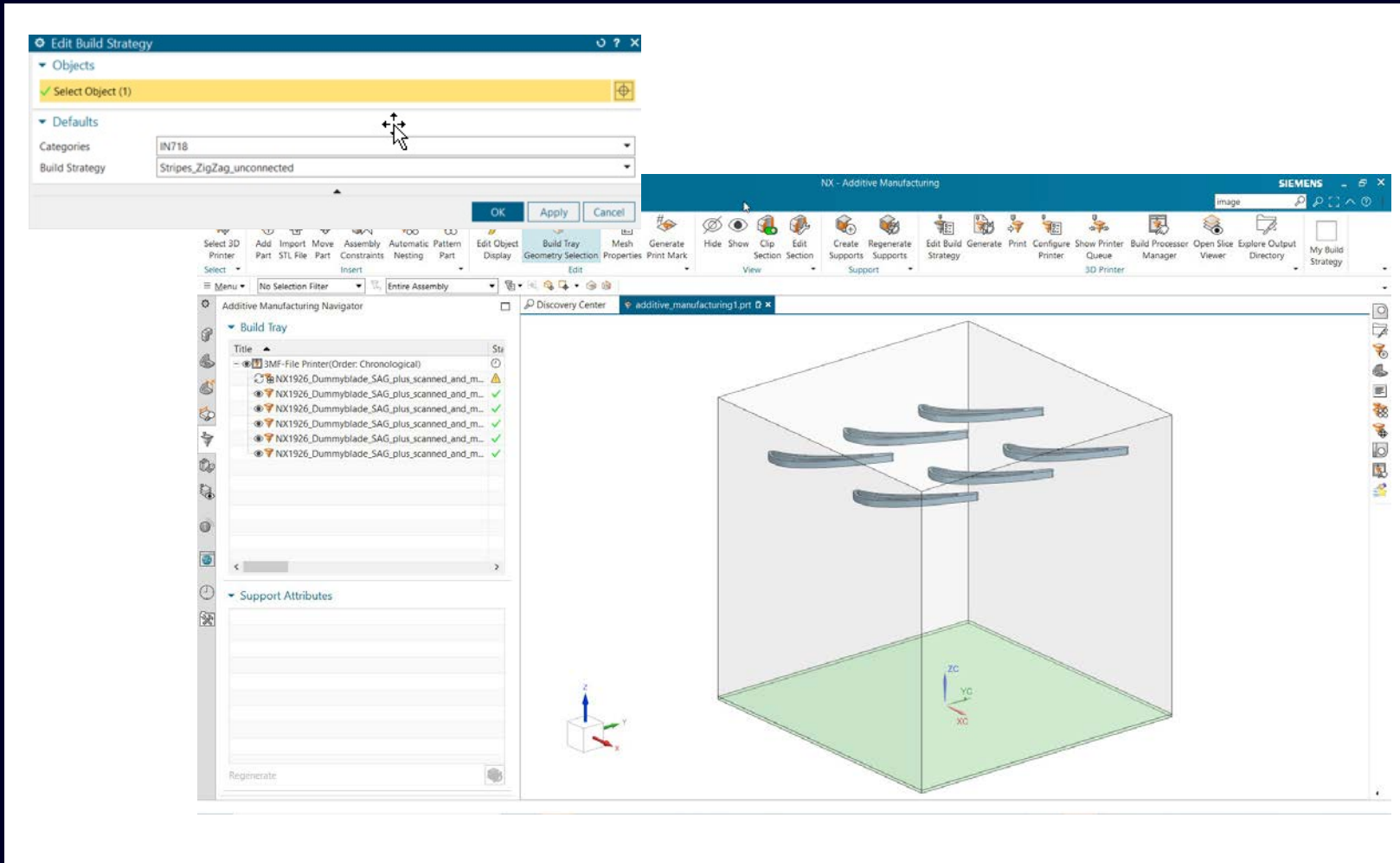
- Use NX OmniMesh Transformer to create an exact B-rep morphed part instance for each scan (blue)
- The images show the small deviations when comparing a morphed part geometry (orange) with the nominal design geometry (grey)

Define the portion to be upgraded and printed versus the remaining part to be reused



- Split each morphed component into a base portion and an upgrade portion
- Define a Reference Set to indicate with portion to print

Print preparation and alignment of a complete set of tips to be printed



- Select the 3D Printer
- Load & position multiple components
- Select the appropriate Reference Set (print only the Upgrade portion)
- Select the Build Strategy, Generate the Print Job File and Print

Efficient orchestration of process incl. powder management & guidance for operator to achieve full traceability



Efficient organization of production activity

Meet your deadlines and delivery dates

Operator guidance

Reduce rework and waste

Production tracking, WIP visibility

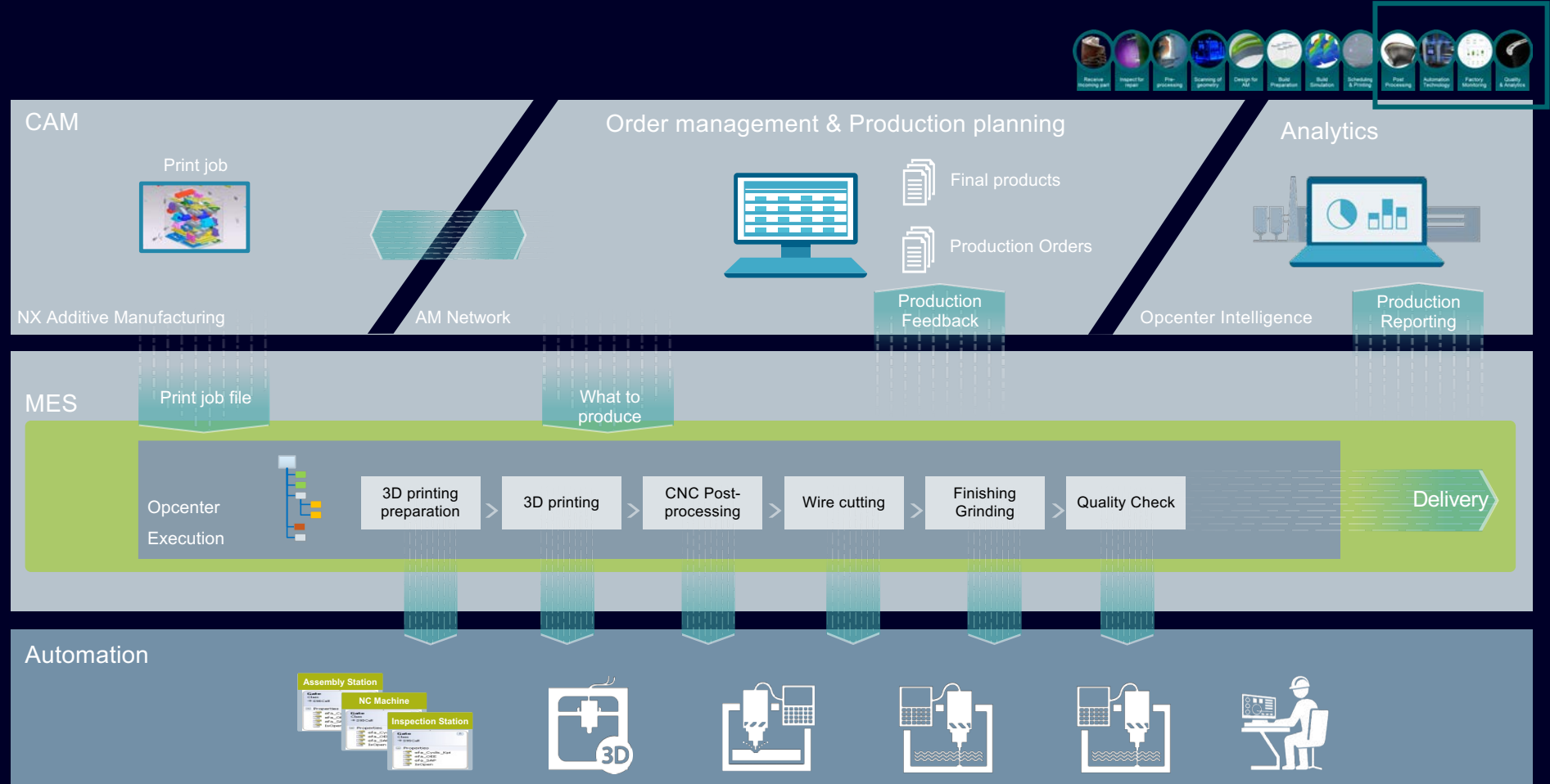
Use your resources efficiently

Quality inspection

Increase reputation and customer satisfaction

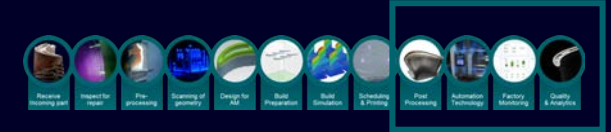
Product genealogy

Meet requirements of regulated industries



Orchestrate production, track and react to deviations

The industrialization continues on the machine level with advanced AM systems, highly productive with multiple lasers



Siemens Digital Industries partners with leading OEMs and offers industrial machine equipment and automation technology

Industrial Security

Industrial Safety

Industrial Communication

Uptime



Finished part:
Repaired and
improved



End-to-end workflow from inspection to printing requires a seamlessly integrated digital thread

Holistic digital thread for metal power bed fusion repair workflow



1

Identify parts for repair and leverage design for AM to improve function and become more sustainable

2

Improve your design to repair workflow and fully automate by end-to-end connected solutions in a unified environment

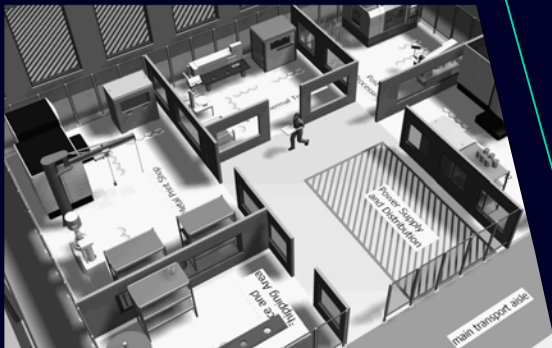
3

Optimize your production by automation and software solutions tailored to actual needs

We industrialize Additive Manufacturing to empower the eco-system to create, make and use additive applications at scale

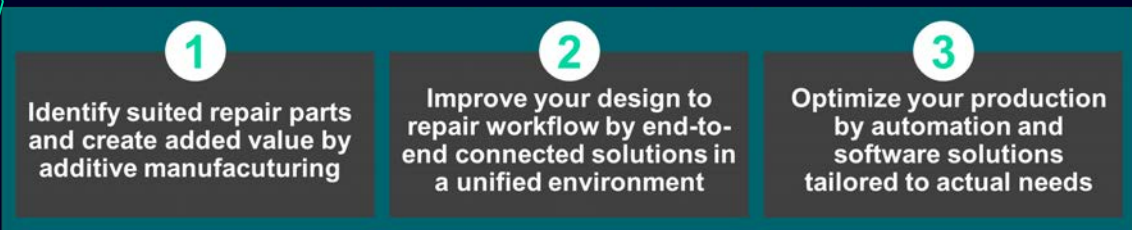


Planning and optimizing in the digital twin of the factory

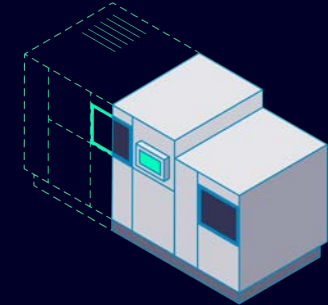


- Material Flow simulation
- Digital Layout Planning
- Collaborative Factory optimization
- Process Simulation for throughput, cost, workforce

Holistic digital thread for metal power bed fusion repair workflow



Smart financing of machine & factory



- Traditional financing of assets with fixed rates
- Partially outcome-based financing of assets and additional services
- Purely outcome-based financing (pay-per-use) by using connectivity to machines



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