

# ETN Additive Manufacturing (L-PBF) machines evaluation



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- Testing scope of component, specimen and powder capsule

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(\*) L-PBF = Laser Powder Bed Fusion

## Task

Evaluation of available L-PBF machines, with proposal aligned with entire ETN AM working group

## Target

Performance of L-PBF machines from different suppliers

## L-PBF Evaluation project Core Team who prepared the proposal

ETN, Engie, Shell, Siemens Energy

## Use case / L-PBF machine evaluation scope:

### Use Case : L-PBF machine supplier evaluation

#### Process

Additive Manufacturing: Laser - Powder Bed Fusion  
Evaluation of components in as-built conditions (with residual stress, etc.). The review will include material and process parameters

#### Target

Comparison of machine performance & productivity from different OEMs

#### Criteria

Process, material, build envelope, quality, productivity, digital integration, transferability, cost, etc.

#### Participants

Machine manufacturers only

#### Setup

Print defined geometry in defined material; tested by neutral organisation & data aggregated by ETN and independent third party

#### Result

Comparison of direct “off the shelf” capabilities of machines

### Print job

#### Material

Nickel Alloy 718 (ASTM F3055 - 14a)

#### Layer thickness

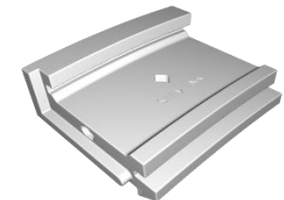
60 µm or 40 µm

#### No post processing

(HIP, surface treatment ...)

#### Components

- Test component : heat shield  
*IP-free design of a high criticality application*
- Charpy impact test specimen
- Tensile test specimen:
- Cubes for Archimedes relative density measurements
- Powder capsule for powder monitoring

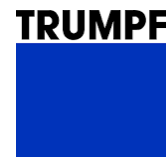


**Machine manufacturers** involved are major actors in the AM sector

**Voluntary participation** of machine manufacturers who can provide “in-kind” production of evaluation components

### Currently involved machine manufacturers

<i>Machine Manufacturers</i>	<i>Equipment Involved</i>	<i>Manufacturing Location</i>
3D Systems	DMP Factory 500	Belgium
EOS	EOS M290	Germany
Farsoon	FS421M	China
Renishaw	Ren500Q	United Kingdom
SLM Solutions	SLM 500	Germany
Trumpf	Truprint 5000	Germany
Velo3D	Tbd	Tbd



### Other invited machine manufacturers

Additive Industries  
The Netherlands

AddUp  
France

Adira  
Portugal

Concept Laser / GE Additive  
US - Switzerland

DMG Mori  
Germany

Matsuura  
Japan

SISMA  
Italy

Sodick  
Japan



The ETN L-PBF Machine Evaluation Initiative provides the ETN Participants with a unique holistic repository of machine's **productivity** and **quality information**

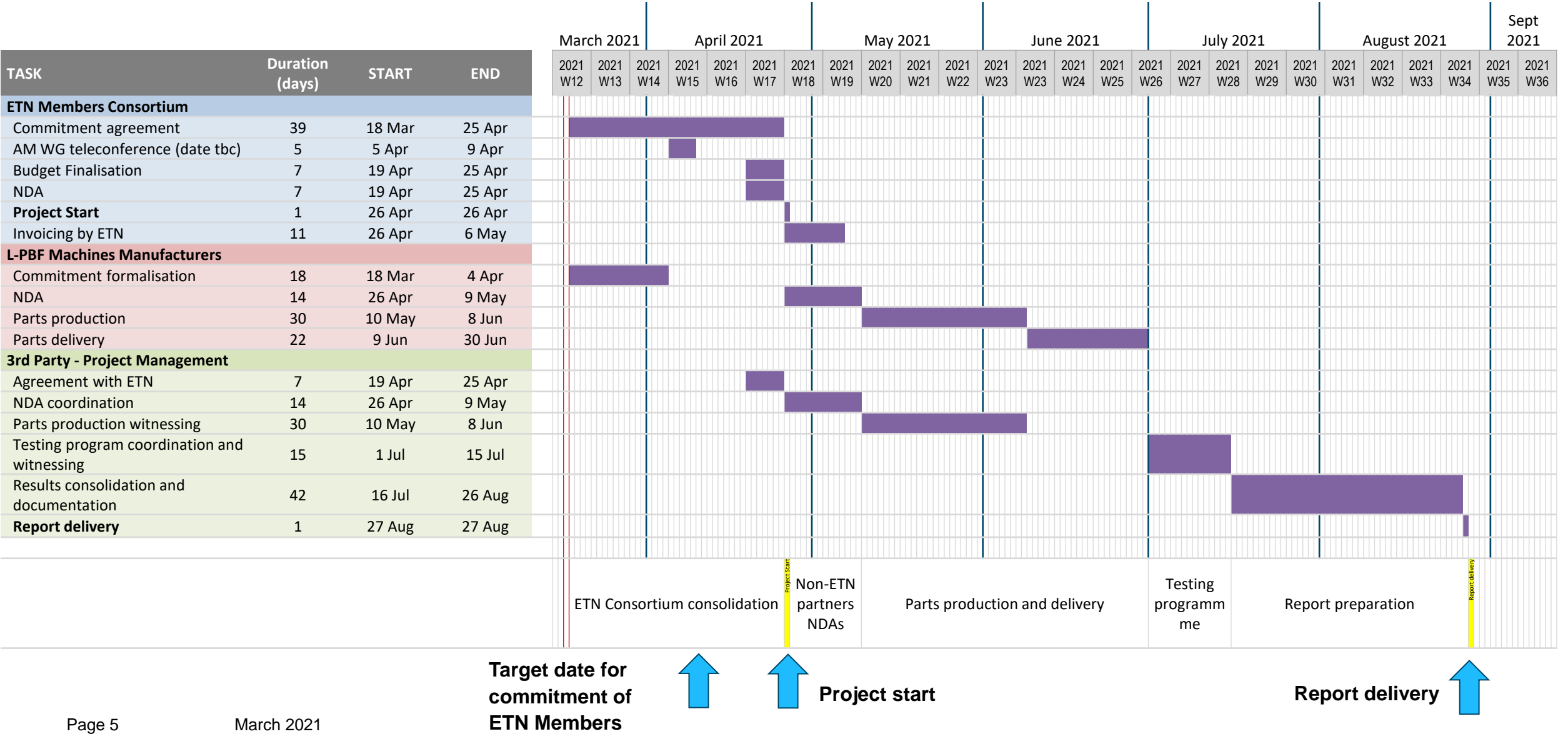
### Project value for involved ETN Members

1. Exclusive access for financiers to the confidential report giving 100% transparency of the evaluation of 6 Laser Powder Bed Fusion machines
2. Unique report providing an overview of market-available equipment, with short project delivery time, based on a 5-month project timeline
3. Detailed insight in achieved results, which are in as-built condition, i.e. without post processing
4. Comparison of both Technical and Commercial KPIs, CAPEX and OPEX, including productivity (based on established standards e.g. ASTM, ISO, NF)
5. Opportunity to compare results of machines which use equal powder, for identical topologies incl. test bars & test component
6. Baseline to potentially compare your machine performance to the 6 ones of this Initiative
7. Database to potentially compare your printing performance
8. Independent reporting (by impartial 3<sup>rd</sup> party) and independent testing (all testing by single sovereign contractor)
9. Enabling an informed decision for machine procurement or contractor selection
10. Access to detailed repository/overview of all machine's technical details
11. Provides information to support qualification of the technology for users
12. Comparatively low participation cost if critical number of ETN financiers is reached



Short project delivery time, based on a 5-month project timeline

Commitment of ETN Members is key to run this initiative



**Unique report** providing an overview of market-available equipment, with **detailed insight** in the achieved results

**Complete transparency** on the evaluation of Laser Powder Bed Fusion machines

**Comparison** of both Technical and Commercial KPIs, CAPEX and OPEX, including productivity

## 1/ Assessment Criteria & Equipment Evaluation Key Performance Indicators (KPIs)

<b>Process basics</b>	<ul style="list-style-type: none"> <li>Machine handling incl. usability &amp; preparation as well as change over time;</li> <li>Ergonomics, layer thickness, re-coater times, bulk parameters, contour parameters, powder utilization / losses</li> </ul>
<b>Material portfolio</b>	<ul style="list-style-type: none"> <li>Variety of materials including standard parameter sets available for machine;</li> <li>Single source vs. multiple suppliers</li> </ul>
<b>Build Envelope</b>	<ul style="list-style-type: none"> <li>in x/y/z determining maximal part size, that can be fitted on the build tray and productivity (maximum number of parts that can be printed in this envelope at one print job)</li> </ul>
<b>Digital integration &amp; data access</b>	<ul style="list-style-type: none"> <li>standard interfaces &amp; machine openness / influenceable variables</li> </ul>
<b>Quality</b> <b><i>Process and Manufactured part</i></b>	<ul style="list-style-type: none"> <li>Process: stability &amp; repeatability influencing machine availability and yield;</li> <li>Manufactured part: observed defects, geometry, microstructure &amp; mechanical performance</li> </ul> <p><u>KPIs</u></p> <ul style="list-style-type: none"> <li>Material properties: static, micro structure, micro grain structure, anisotropy, feature resolution &amp; accuracy, dimensional tolerances, residual stress</li> <li>See also the testing scope</li> </ul>
<b>Productivity</b>	<ul style="list-style-type: none"> <li>Simulation &amp; experiment in terms of time &amp; costs per part (e.g. maximum number of parts that can be printed in the envelope at one print job, incl. with components stacking)</li> </ul>
<b>Transferability</b>	<ul style="list-style-type: none"> <li>of frozen build parameter sets from one machine to other of same type, same supplier, same technology</li> </ul>
<b>Costs</b>	<ul style="list-style-type: none"> <li>Cost for printed part, CapEx &amp; OpEx</li> </ul>



## Machine's technical details

Access to detailed repository/overview of all machine's technical details

## Testing results

Opportunity to compare results of machines which use equal powder, for identical topologies

## 2/ Equipment technical documentation & Print job log information

- Model
- Process basics
- Material portfolio
- Build envelope
- Digital integration & data access
- Availability of quality monitoring system
- Number of power sources (multi-laser allowed)
- Cost of one machine (HW cost, maintenance cost, service costs; max running hours, guaranteed uptime)
- Print job log information

## 3/ Testing scope & geometries

Mechanical testing							Metallurgical analysis and NDT		
Tensile testing at room temperature	Bend testing	Bend test after corrosion test	Charpy impact testing at room temperature	Hardness measurement at room temperature	Archimedes relative density measurements	Powder capsule characterization	Destructive examination by optical microscopy	Destructive examination by scanning electron microscopy	Surface / Volumetric NDT

Powder				
Chemical composition	Particle size distribution	Particle morphology	Flowability	Trace elements

**Comparatively low participation cost** if critical number of ETN financiers is reached

## Budget & Costs considerations

- Machine manufacturers** to deliver evaluation parts on a voluntary basis ("in-kind" production of evaluation components) and thus use this evaluation initiative for business development purposes
- Third party**
  - project management and independent assurance that the participants adhere to the conditions and requirements of the initiative
  - follow industry practices for the gathering and consolidation of data, and ensure traceability of results – standard ASTM F3303-2018
  - witness of printing and/or testing activities
  - provide a report of evaluation result
- Powder & Testing Program**  
Neutral entity will carry out the assessment program and characterize the parts (universities, R&D centers...)

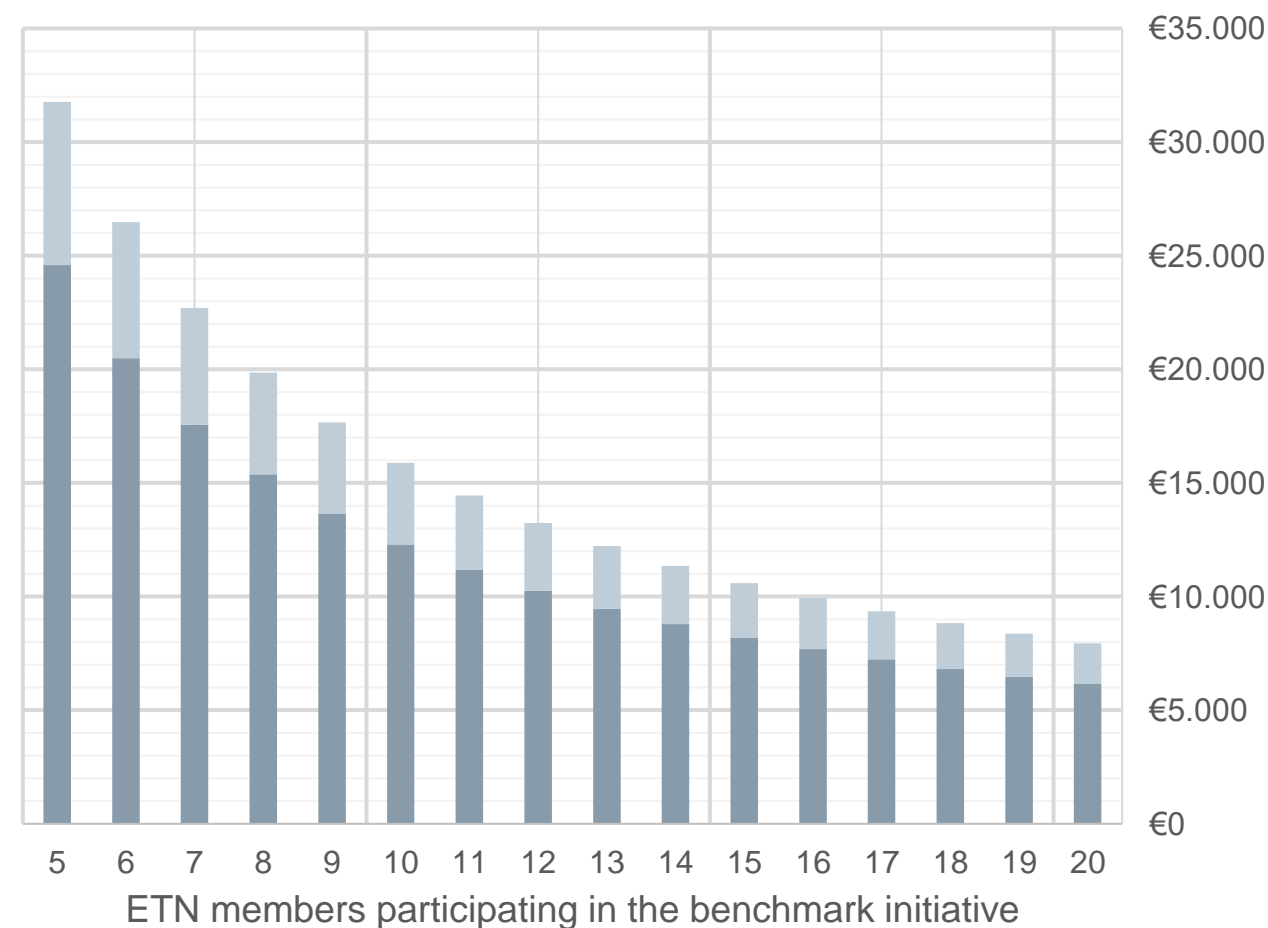
## Individual financial contribution

*Based on 6 machine manufacturers*

ETN members	1 job/participant with ETN powder	1 job/participant with ETN powder + 3 extra jobs with OEM Powder (*)
1	€122,986	€158,890
5	€24,597	€31,778
10	€12,299	€15,889
15	€8,199	€10,593
20	€6,149	€7,945

(\*) 3DSystems, Renishaw, SLM Solutions

ETN Member Contribution based on 6 Machine Manufacturers



■ 1 print job per participant, ETN Powder  
■ 3 extra print jobs, OEM powder



### **Contact us**

ETN Members interested in joining this initiative are invited to contact Valentin Moëns ([vm@etn.global](mailto:vm@etn.global)).  
Clarifications on budget or time constraints are encouraged

### **Follow-up meeting with ETN AM Working Group**

7 April (tbc)

Dedicated meeting to discuss the topic in details

### **Target date for commitment of ETN Members**

25 April 2021