Certification and qualification in AM

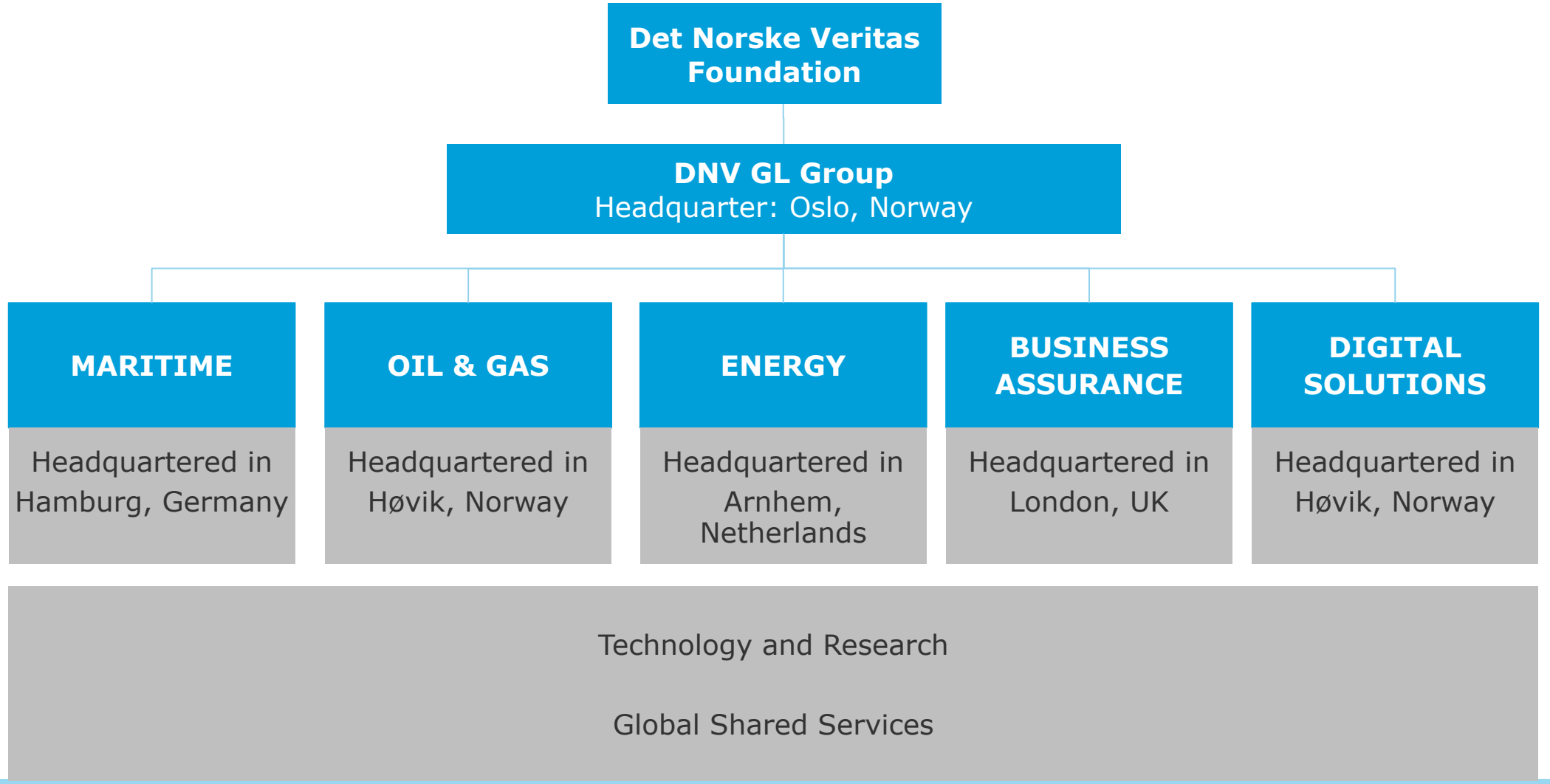
AM-dagen: 3D-printmuligheter i Stavanger-regionen

12 September 2019

Content

- **About DNV GL**
- About AM
- AM initiatives at DNV GL
- ProGRAM JIP
- Certification & qualification

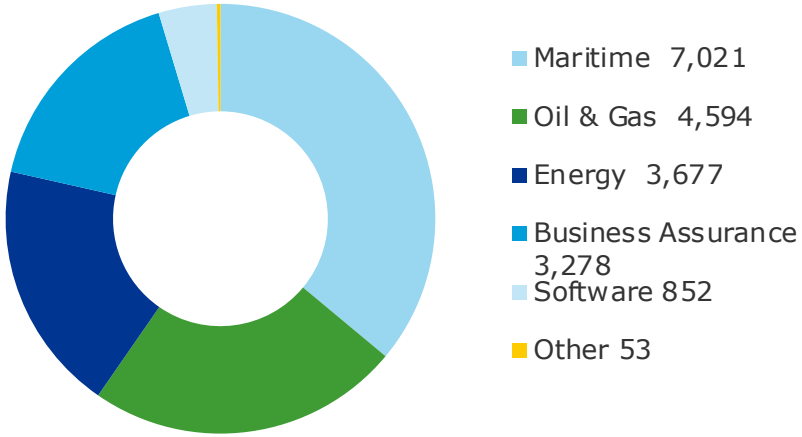
Independent, autonomous and industry-focused organization



Revenue and people by business area

Revenue (million NOK)

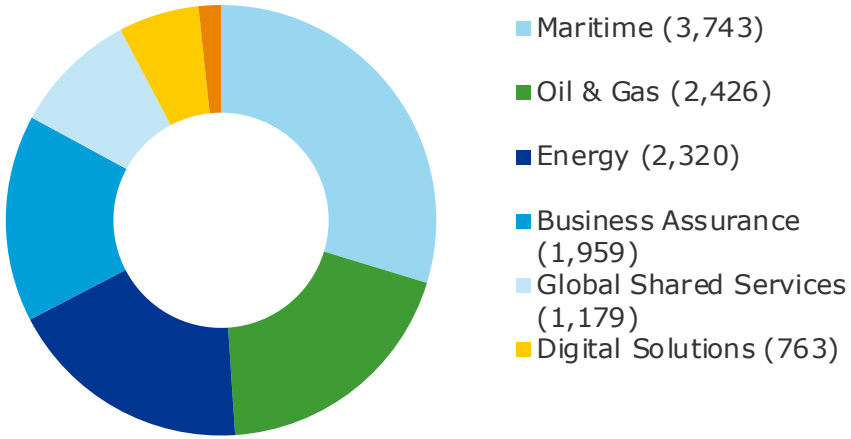
19,475



Figures as of 31 Dec 2017.
Software became part of Digital Solutions 1 Jan 2018

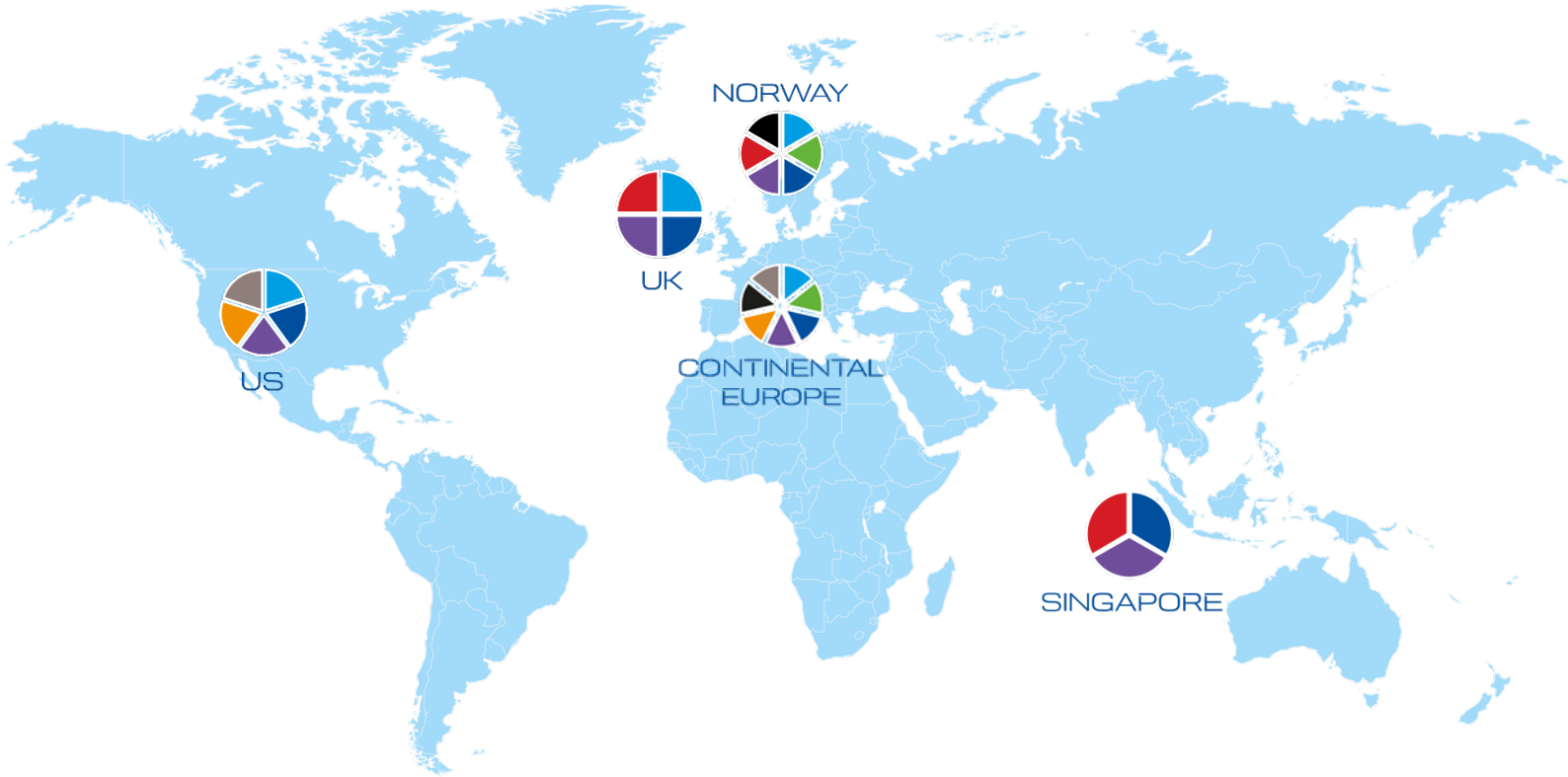
Number of employees by business area

12,601



As of 1 Jan 2018.

Putting our expertise to the test: 14 laboratories across 3 continents



- Environmental laboratory services
- Failure investigation
- Flow testing and calibration
- Full scale testing
- Materials qualification and testing
- Verification and testing of control systems software
- High-power/High-voltage testing
- Battery and energy storage testing

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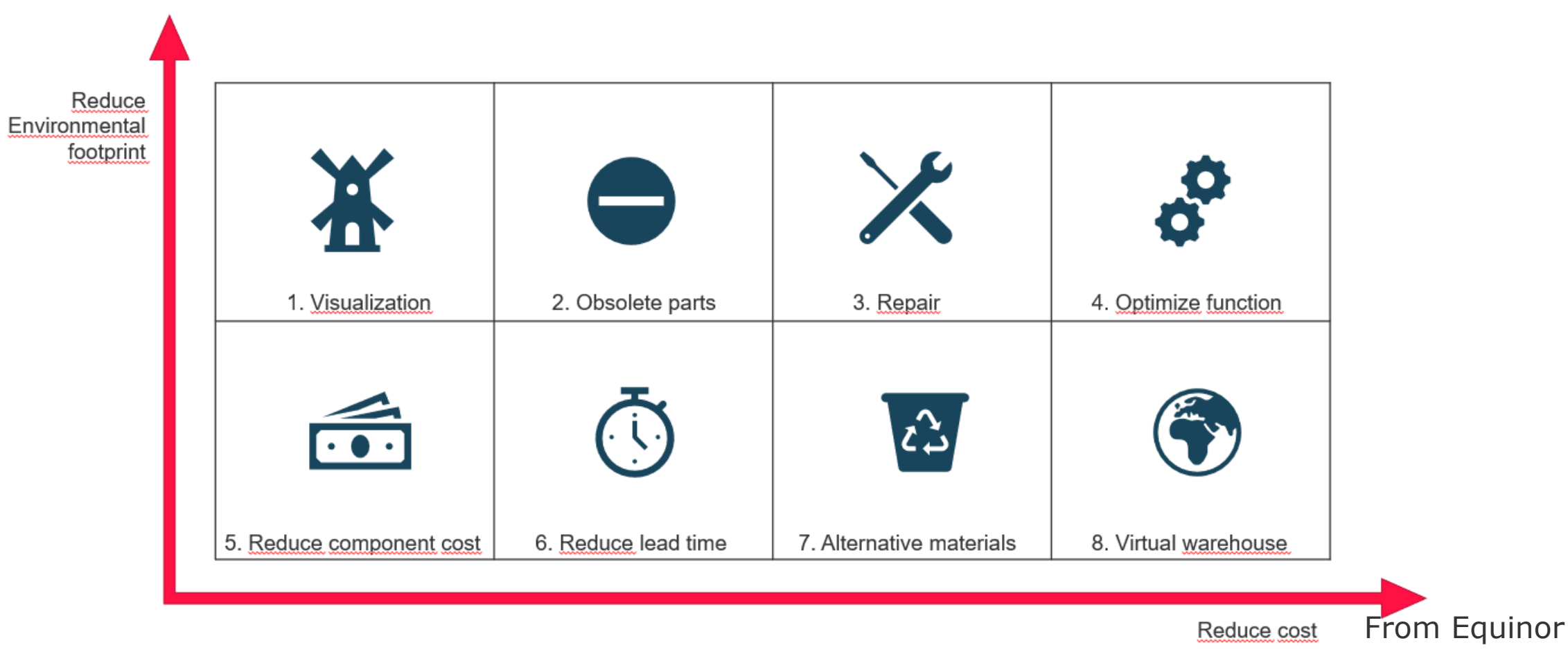
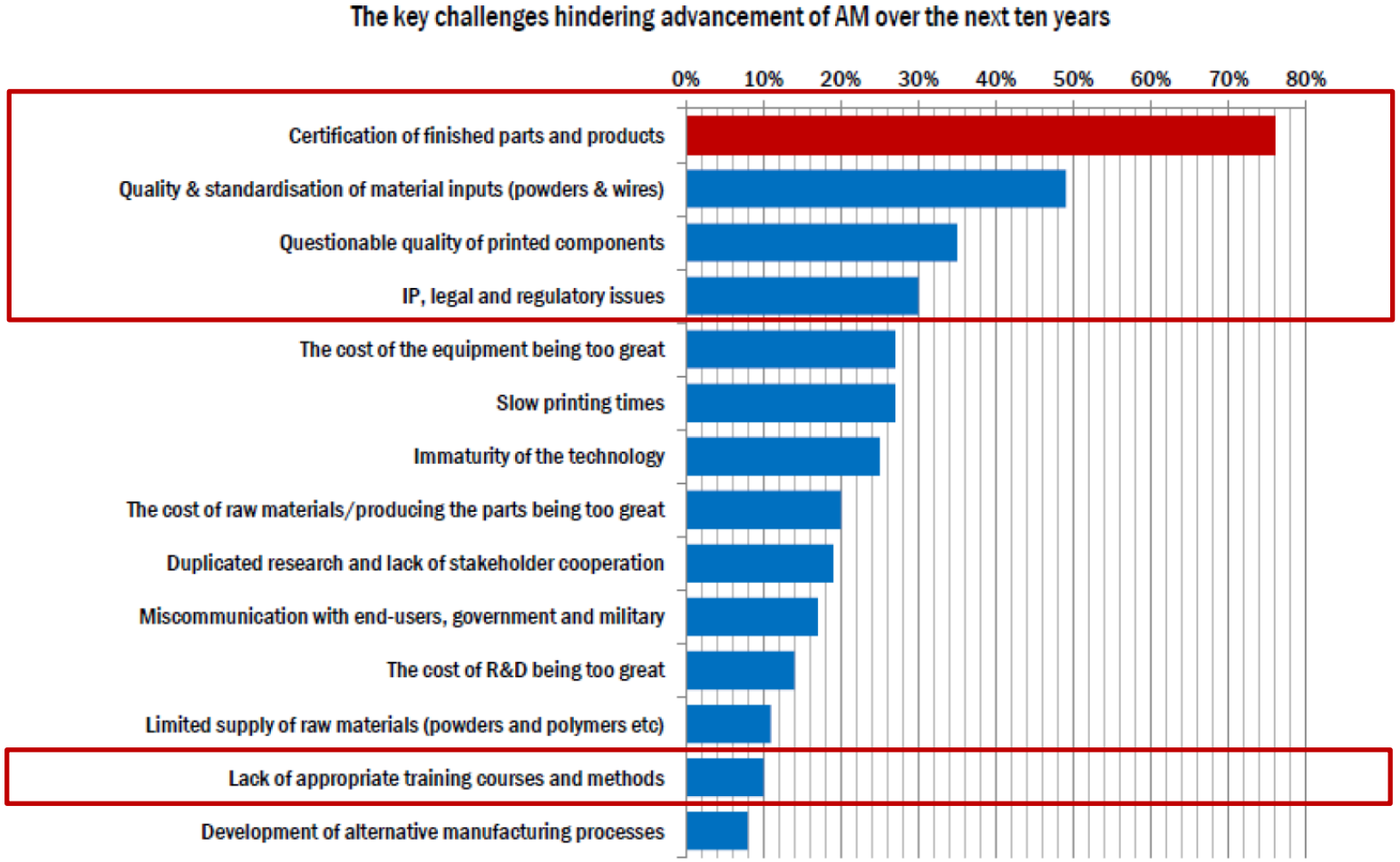
Why AM in O&G?



From Equinor

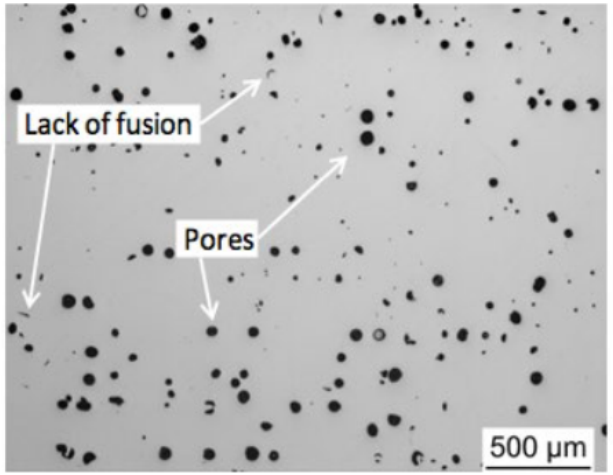
Our role in AM

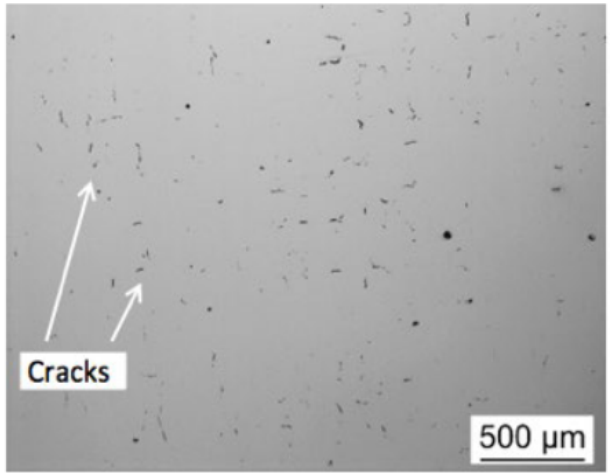


Source : AM in Aerospace, Defence and Space, Trends and Analysis, Defence iQ survey, 21-23 Feb 2017, London, UK

What may go wrong?

- In case of incorrect process parameters, build strategy, part orientation or insufficient powder quality, some typical defects can be observed:
- Unmolten powder particles
- Lacks of fusion
- Pores
- Cracks
- Inclusions
- Residual stresses
- Poor surface roughness





When all goes well

Traditional production
10,8 kg

Metal 3D printing
1,5 kg

Source : Aidro, Italy

- This is a 3D printed Heat Exchanger for water-oil made with Additive Manufacturing in Aluminum (AlSi10Mg).
- It exchange 12 kW and compared to the conventional Heat Exchanger its size is 1/5.

3D printing advantages:

- High performances in small size
- Possibility to combine multiple parts into one
- 1/5 size dimension
- 85% weight reduction

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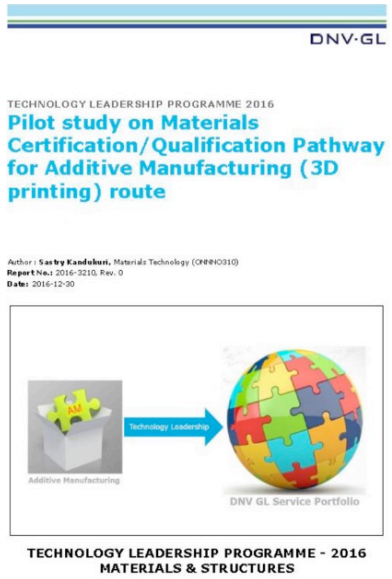
DNV GL Classification Guideline CG-0197: Additive manufacturing - qualification and certification process for materials and components



DNV GL has researched the requirements for successful use of additive manufacturing since 2014

DNVGL AM status 2018 & 2019

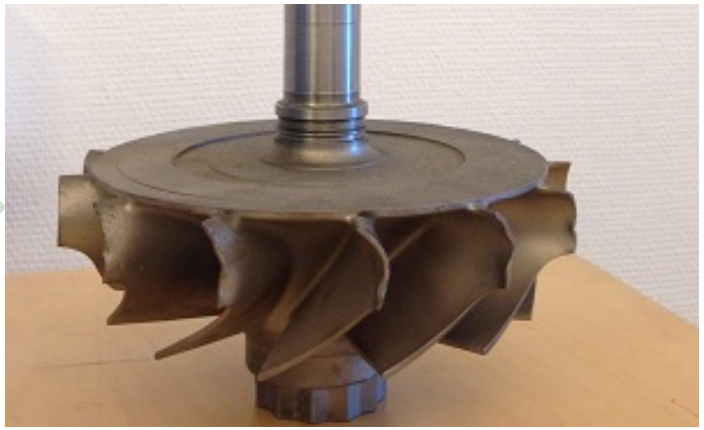
Green ship of future- Denmark Danish Maritime

PJ Diesel Engineering, Denmark

Force Technology, Denmark

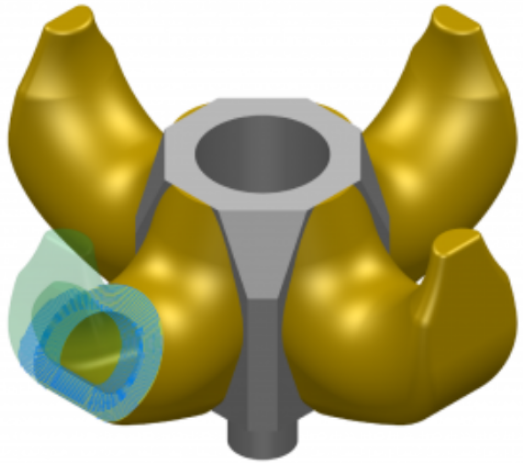
KBB, Germany

- Laser cladding for Turbo charge repair -
- Project completion in April 2018



Huisman – Netherland

- Crane Hook by Wire Arc Additive Manufacturing
- Project started in March 2018 and expected to complete April 2019



Internal DNV GL project: Qualification and certification AM components by use of data analytics

- Challenges for AM components.
- Difficult to perform testing of materials properties for all locations for AM components due to often complex geometries, where properties in different part may be highly manufacturing process dependent.
  - Anisotropy – depending on building direction
  - Heat treatment
- AM techniques produces various defects – which restrict the use in critical components
  - Crack-initiating pores
  - singe pore sizes versus pore fractions

Use new non destructive methods
Micro CT

Growing need for predictive models

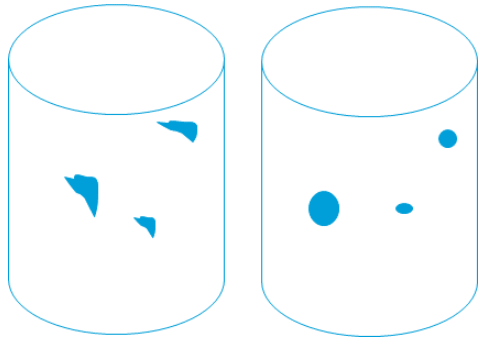
Rapid Qualification
Certification

– Short term

- Exploration of FEA capability to capture anisotropic properties and damage evolution in 718 AM materials with different manufacturing routes
  - Mechanisms: Damage evolution under monotonic loading

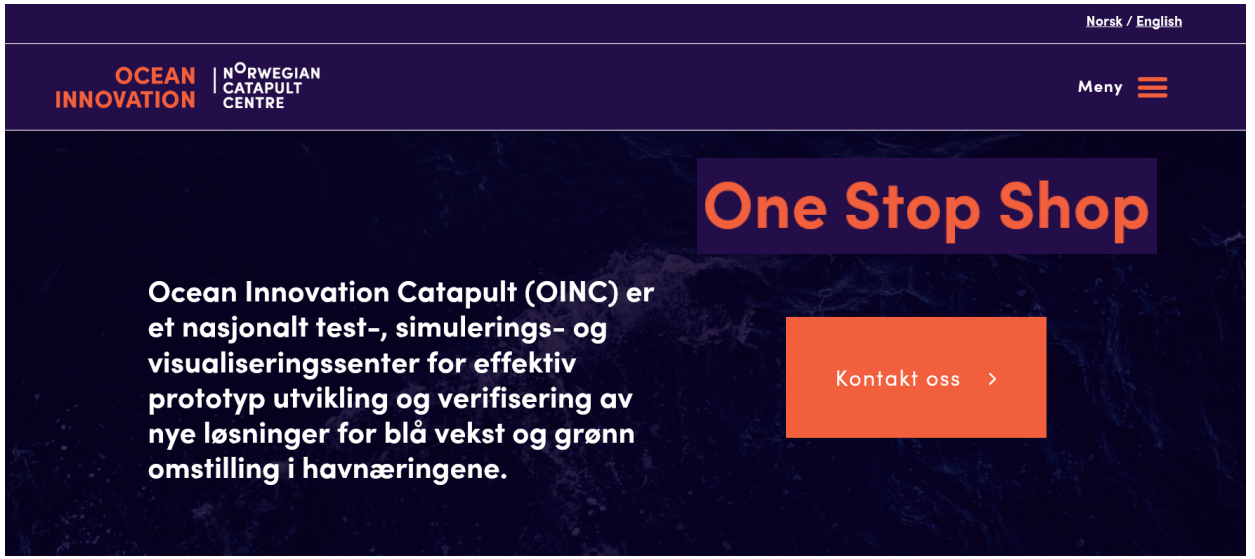
– Longer term

- Development of FEA procedures for use in rapid qualification and certification of AM components
- Mechanisms: Inclusion of cyclic and environmental effects



Ocean Innovation Norwegian Catapult Centre (OINC)

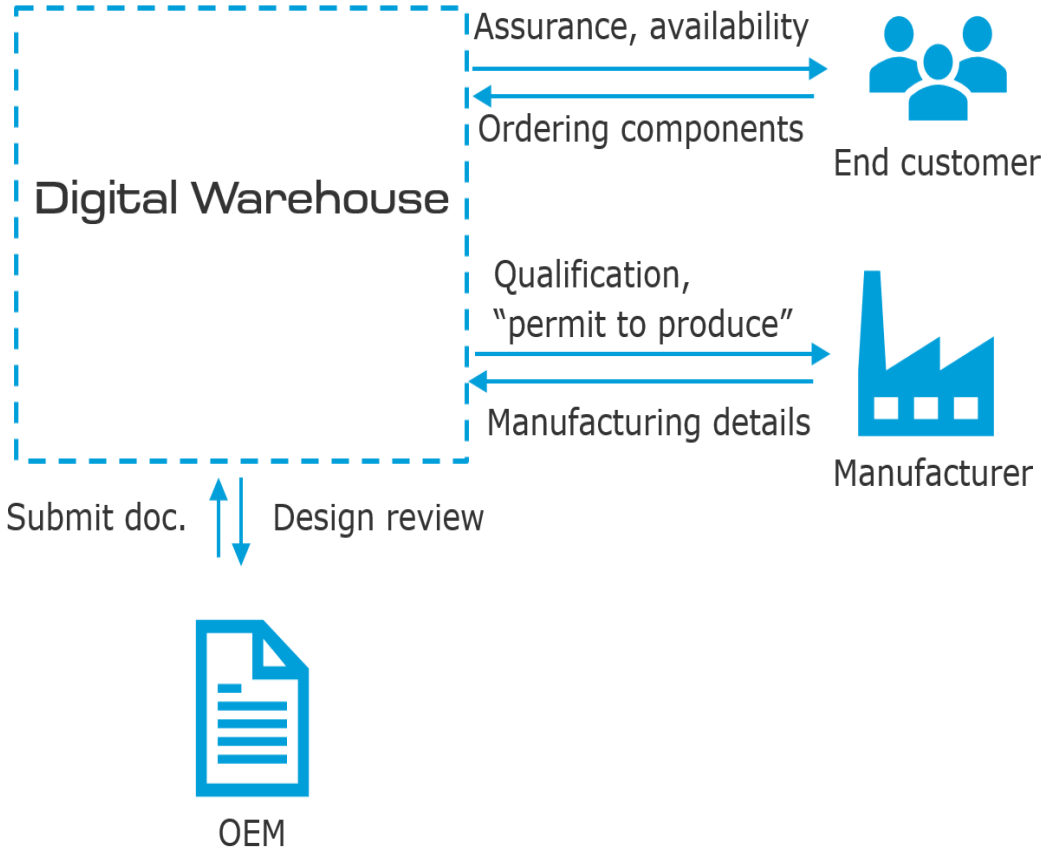
- OINC nå formlet etablert som selskap I mars (og kommer tildelte midler +70 MNOK)
- Daglig leder + 1 ekspert ansatt
- Ambisjon om lokal 3D print kapasitet på Marineholmen i Bergen ila 2019
- DNV GL som kvalifiseringspartner og "testhus"



- **Formål;** Bidra til at bedriftene raskere, rimeligere og bedre evner å utvikle idèer fra konseptstadiet og frem til markedsintroduksjon.
- **Målgruppe;** Små og mellomstore bedrifter, men også store bedrifter, FoUI-miljøer og utdanningsinstitusjoner.
- **Tilbud;** Utleie av utstyr, kompetanse og lokaler - der bedrifter kan teste, simulere eller visualisere teknologier, komponenter, produkter, løsninger, tjenester og prosesser.

Digital warehouse of spare parts – JIP Call for partners

- O&G and Maritime - large inventory
- Long lead times
- Bring together key industry stakeholders to identify and address the unique challenges associated with the digitalization of spare parts
- No platform but systematics. Some ideas
  - Feasibility
  - Roles and responsibilities in the AM network
  - Digital thread
  - Readiness level



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ProGRAM JIP – Qualification of AM products

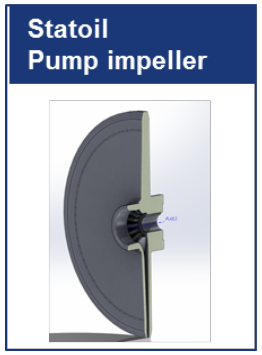
- Objective - to develop requirements necessary to introduce components made by AM for Oil and Gas and related applications.
- Deliverable - project guideline that can be issued as a DNV GL recommended practice.
- Participants: 16, whole value chain

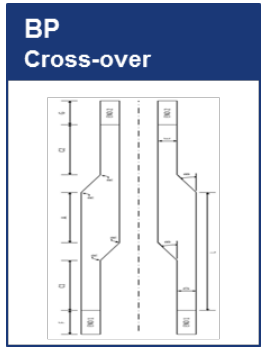
Aim of the JIP(s)

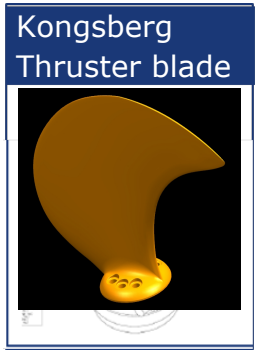
- Two JIPs in one:
  - Berenschot: Development of business cases for AM parts.
  - DNV GL: Development of guideline for metal AM in the O&G and Maritime industry.

- Involvement of entire value chain, to be able to control the full AM process within the project

- Assessing, redesigning, manufacturing and testing of actual components (>7)







Participating companies

Operators	Contractors	Fabricators
bp	SLM SOLUTIONS	ArcelorMittal
equinor	TechnipFMC	ivaldi
Shell	IMI Critical Engineering	voestalpine
TOTAL	KONGSBERG	aidro hydraulics
	SIEMENS	Additive Industries
		vallourec
		University of Strathclyde Glasgow
		IMMENSA TECHNOLOGY LABS
		SANDVIK
		HIPtec
		Quintus TECHNOLOGIES

Guideline for additive manufacturing

- AM technologies: WAAM and PBF

- Different consequence of failures – different qualification routes; AM Class 1, 2 and 3
  - AM Class 1: Ensuring the build process
  - AM Class 2: Ensuring repeatability of the build process
  - AM Class 3: Ensuring the part

- The guideline addresses topics of concern identified in an FMECA

- Ensuring practicality of guideline through part production

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DNVGL rule allows AM Component

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RULES FOR CLASSIFICATION

Ships

Edition January 2017
Amended January 2018

Part 2 Materials and welding

Chapter 1 General requirements for materials and fabrication

DNV GL AS

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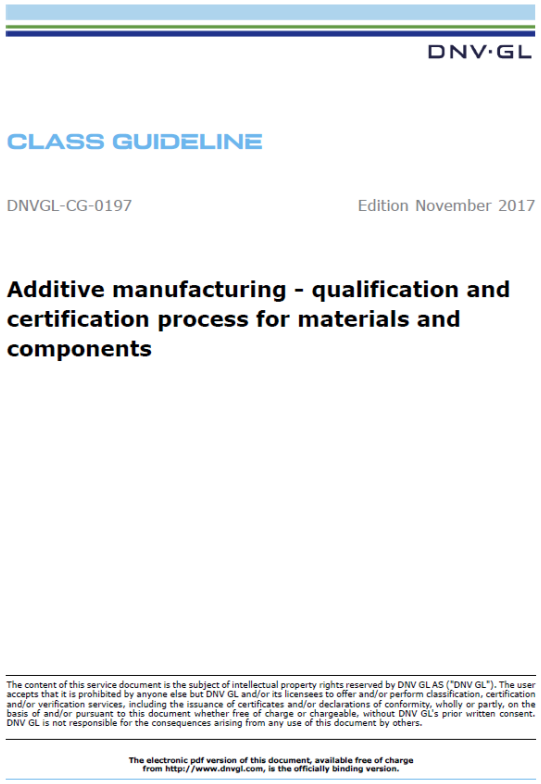
OFFSHORE STANDARDS

DNVGL-OS-B101 Edition January 2018

Metallic materials

DNV GL AS

AM documents



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CLASS GUIDELINE

DNVGL-CG-0197 Edition November 2017

Additive manufacturing - qualification and certification process for materials and components

2017

DNV·GL

CLASS PROGRAMME

Approval of manufacturers

DNVGL-CP-0267 Edition July 2018

Additive manufacturing

2018

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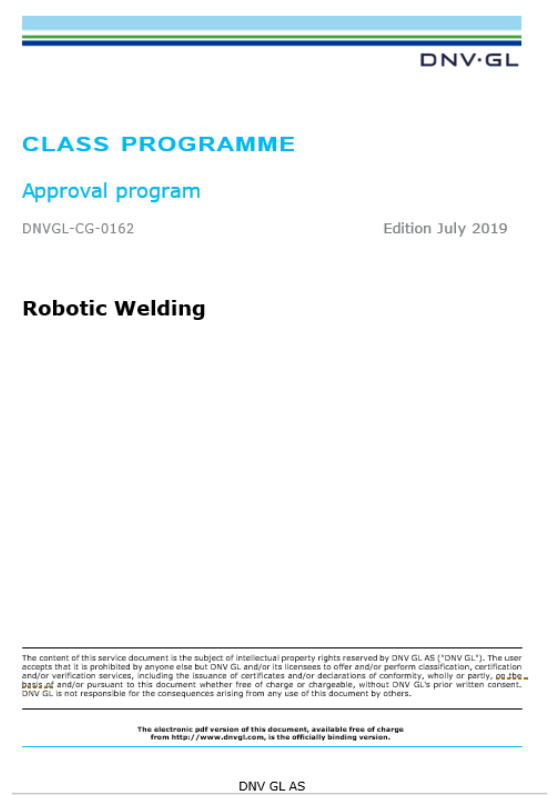
CLASS PROGRAMME

Type approval

DNVGL-CP-0291 Edition June 2019

Additive Manufacturing - Feedstock

New



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CLASS PROGRAMME

Approval program

DNVGL-CG-0162 Edition July 2019

Robotic Welding

To be released

Certification pathway for AM (3D printing)

Request for Certification

Evaluation

Marine /O&G

Technology Assessment → Statement of Feasibility

Manufacturing Procedure Qualification (MPQ) → Approved Manufacturing Procedure

Class

Approval of Manufacturer (AoM) → AoM Certificate

Material Certification → Class/Works Certificate

Non-Class/ Voluntary

Feasibility Study → Feasibility Report

Technology Qualification → Technology Certificate

Approved Service Supplier (AoSS) → AoSS Certificate

Type Approval (TA) / Case-by-Case Design Approval → TA Certificate

Component/Product Certification → Certificate

ProGRAM JIP guideline

Classification on component–Certificates

Conventional Techniques (Casting, Forging, etc)

High Risk			★
Medium		★	
Low Risk	★		
	Test Reports	Work Certificates	Product Certificates

AM Techniques (WAAM & DED)

High Risk			★
Medium			★
Low Risk		★	
	Test Reports	Work Certificates	Product Certificates

Test Report, TR – only manufacture certificate

Work Certificate, W/3.1 –Type approval certificate (TA), and Approval of manufacturer (AoM)

Product Certificate, VL – As for W/3.1 but DNVGL Survey of actual product as well

After the qualification schemes are in place, the future of AM looks bright

Thank you for your kind attention.

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