

AM day

Universitetet i Stavanger

10 March 2020

Content

- **About DNV GL**
- AM & DNV GL
- AM initiatives at DNV GL
- Qualification

Global reach – local competence

12,000

employees

150+

years

100+

countries

100,000+

customers

5% R&D

of annual revenue

MARITIME



OIL & GAS



ENERGY



**BUSINESS
ASSURANCE**



**DIGITAL
SOLUTIONS**



Technology & Research

Global Shared Services

We apply deep insights and diverse industry domain competence

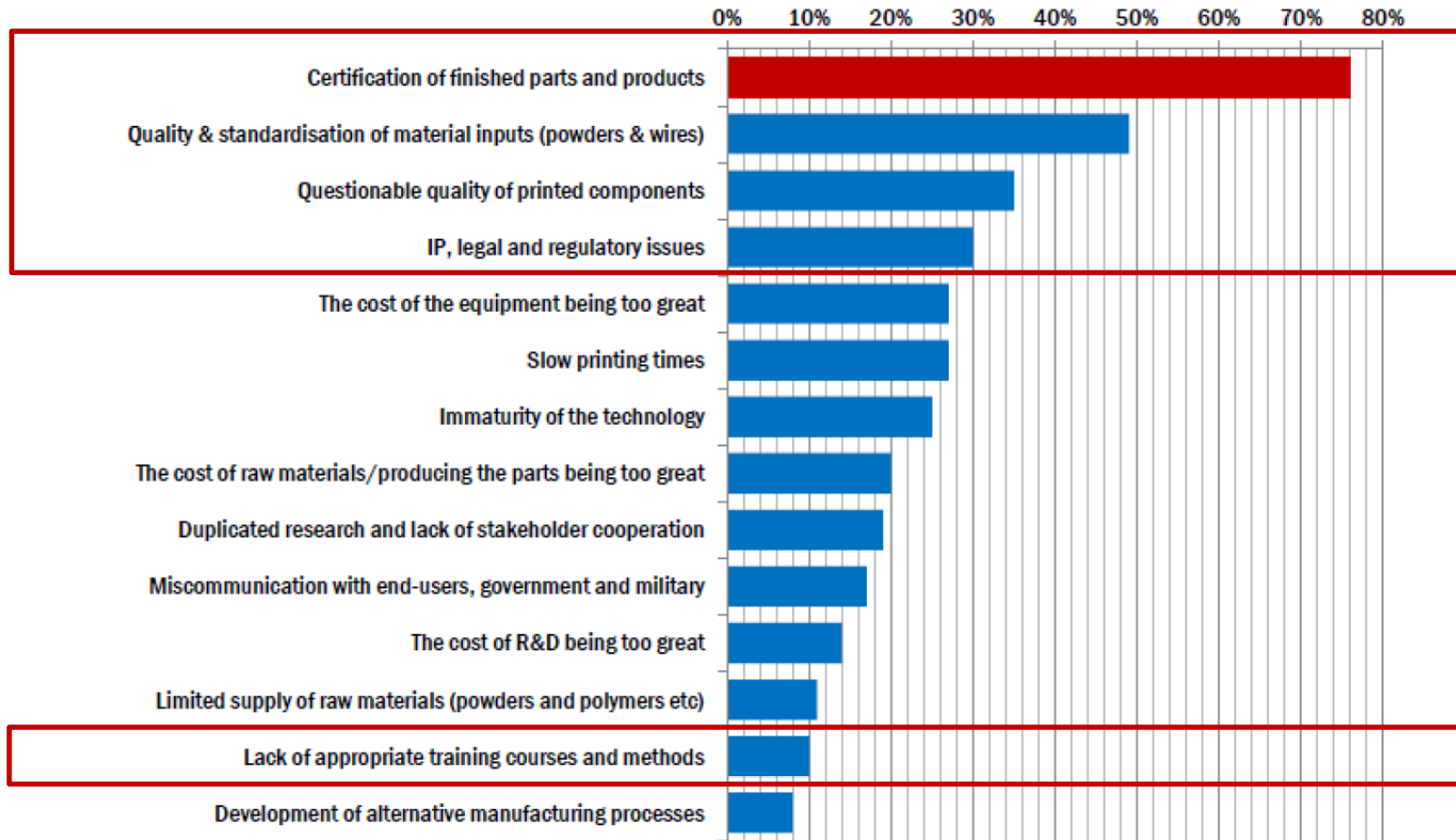
- 
- We **classify, certify, verify and test** against regulatory requirements, standards and recommended practices
 - We develop new **rules, standards and recommended practices**
 - We **qualify new technologies** and operational concepts
 - We give **expert advice** on safety, technology, data management, efficiency, performance, and risk management

Content

- About DNV GL
- **AM & DNV GL**
- AM initiatives at DNV GL
- Qualification

Our role in AM

The key challenges hindering advancement of AM over the next ten years



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

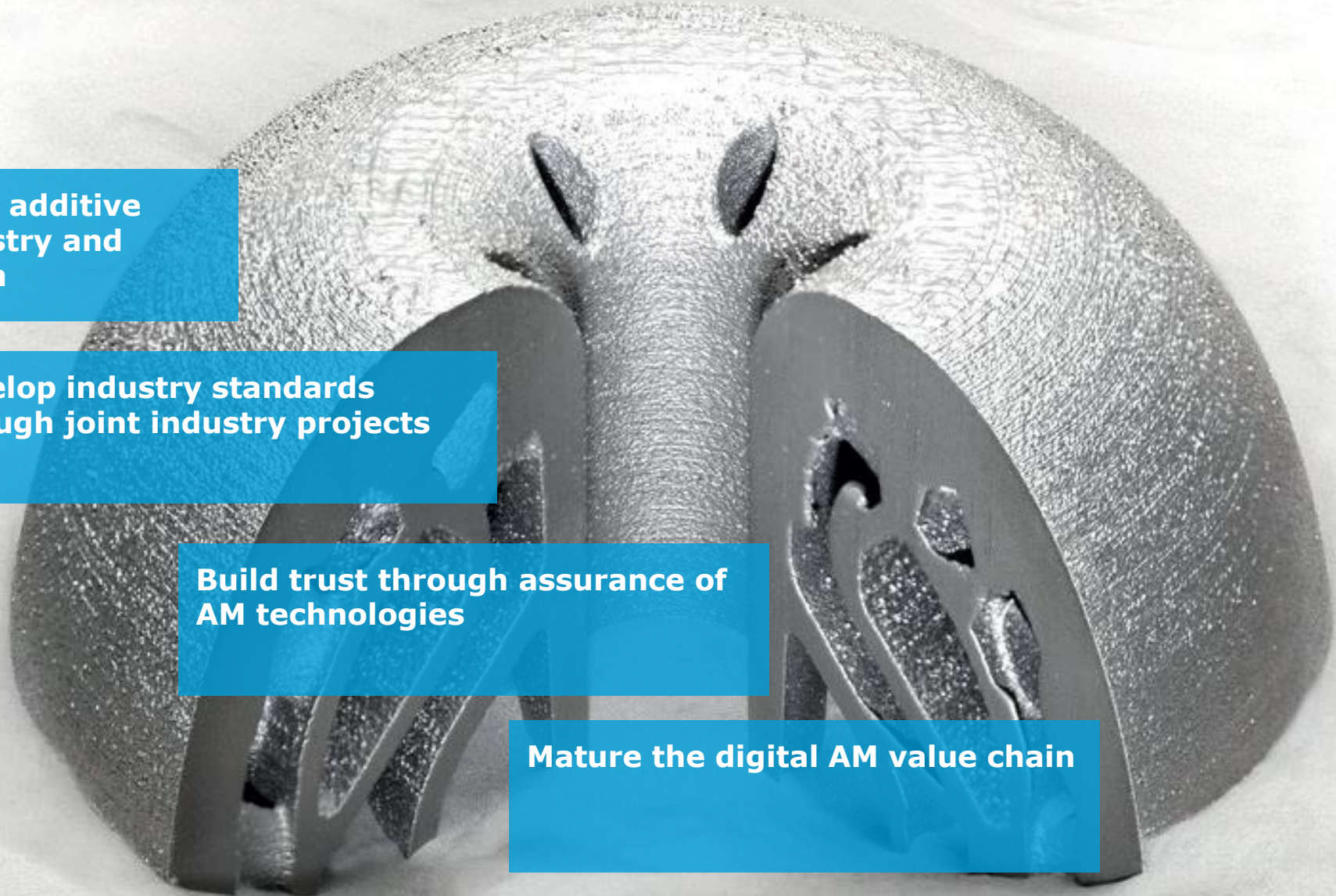
DNV GL's ambition within additive manufacturing

Collaborate with the additive manufacturing industry and shape the discussion

Develop industry standards through joint industry projects

Build trust through assurance of AM technologies

Mature the digital AM value chain



Content

- About DNV GL
- AM & DNV GL
- **AM initiatives at DNV GL**
- Qualification

ProGRAM JIP

ProGRAM JIP

| Operators | Contractors | Fabricators | |
|---|---|---|--|
|     |      |      |      |

ProGRAM JIP

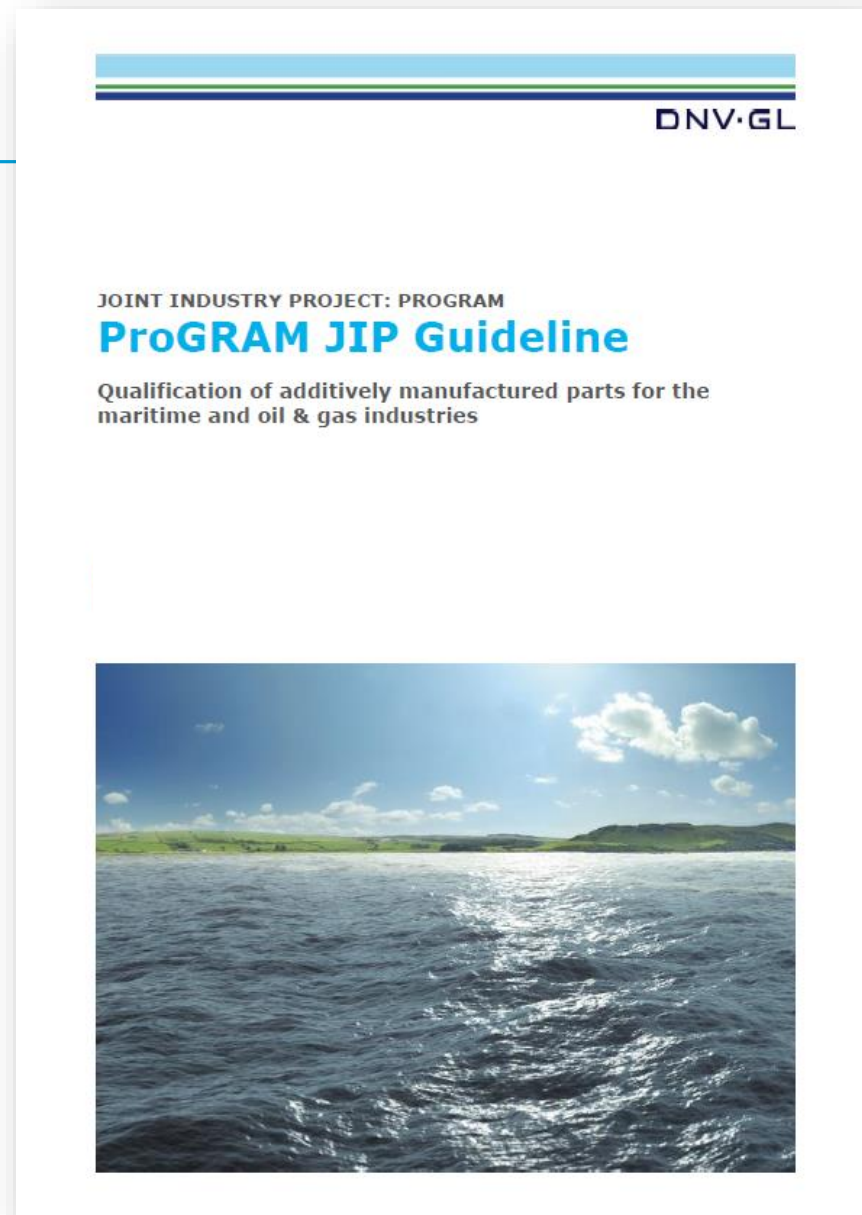
- Objective - to develop requirements necessary to introduce components made by AM for Oil and Gas and related applications.
- Deliverable - project guideline that can be issued as a DNV GL recommended practice.
- Participants: 20, whole value chain



ProGRAM JIP

- Additive Manufacturing
 - WAAM
 - PBF-LB

- Criticality based qualification route:
 - AM Category 1
 - AM Category 2
 - AM Category 3



ProGRAM JIP

Table of contents

| | | | |
|--|----|--|----|
| ACKNOWLEDGEMENTS: | II | | |
| 1 GENERAL..... | 1 | 4 TECHNICAL REQUIREMENTS | 23 |
| 1.1 Introduction | 1 | 4.1 General | 23 |
| 1.2 Objective | 1 | 4.2 Pre-build requirements | 23 |
| 1.3 Scope | 1 | 4.3 Build requirements | 24 |
| 1.4 Application | 2 | 4.4 Post processing requirements | 25 |
| 1.5 Alternatives to requirements | 3 | 4.5 Repair | 26 |
| 1.6 Roles and responsibilities | 3 | 5 TESTING REQUIREMENTS | 27 |
| 1.7 Additive Manufacturing Category | 4 | 5.1 General | 27 |
| 1.8 Purchase order information | 5 | 5.2 Tensile testing | 27 |
| 1.9 Normative and informative references | 6 | 5.3 Impact testing | 28 |
| 1.10 Verbal forms | 9 | 5.4 Bend testing | 28 |
| 1.11 Terms and definitions | 10 | 5.5 Hardness testing | 29 |
| 1.12 Abbreviations | 12 | 5.6 Microstructural assessment | 29 |
| 2 QUALITY ASSURANCE METHODOLOGY | 14 | 5.7 Porosity measurement | 30 |
| 2.1 General | 14 | 5.8 Chemical analysis | 31 |
| 2.2 Build process qualification testing | 14 | 5.9 Dimensional check | 31 |
| 2.3 Part qualification testing | 14 | 6 NON-DESTRUCTIVE TESTING | 32 |
| 2.4 Production testing | 15 | 6.1 General | 32 |
| 3 QUALITY ASSURANCE AND QUALITY CONTROL..... | 16 | 6.2 Personnel requirements | 32 |
| 3.1 General | 16 | 6.3 Visual testing | 33 |
| 3.2 Quality management system | 16 | 6.4 Surface testing | 33 |
| 3.3 Manufacturing documentation | 16 | 6.5 Volumetric testing | 34 |
| 3.4 Personnel requirements | 19 | | |
| 3.5 HSE requirements | 20 | Appendix A Wire Arc Additive Manufacturing | |
| 3.6 Quality control | 20 | Appendix B Laser-based Powder Bed Fusion | |
| 3.7 Feedstock | 21 | Appendix C Templates | |
| 3.8 Equipment and maintenance | 21 | Appendix D Qualification pathways | |
| 3.9 Delivery | 21 | | |
| 3.10 Traceability | 22 | | |

ProGRAM JIP Guideline

- **Build process qualification:**

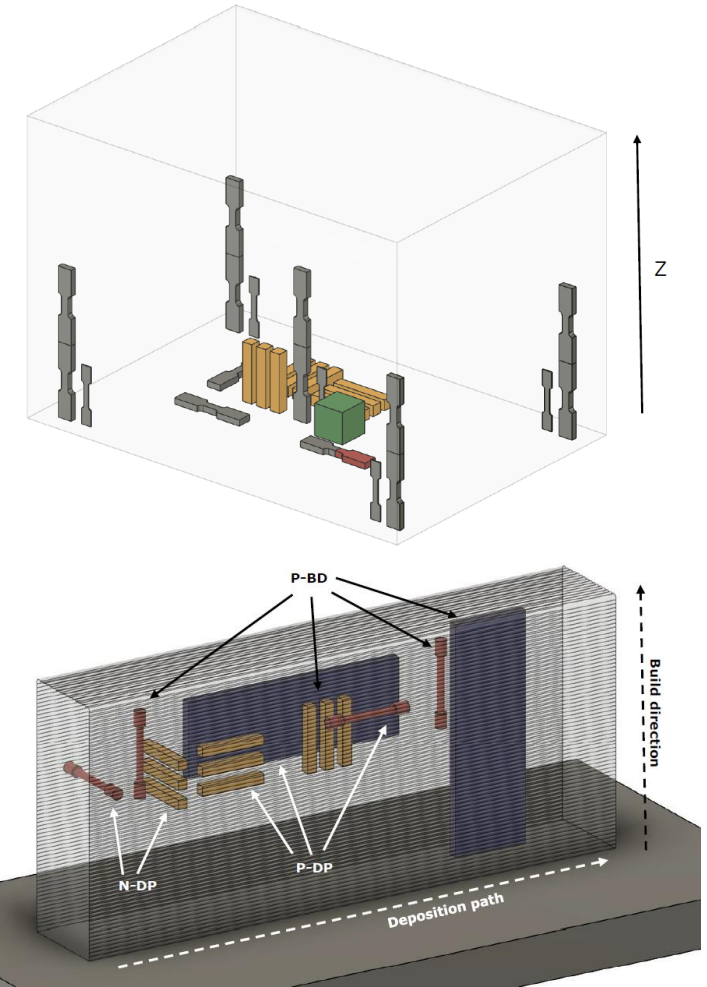
- Predefined set of test specimens.
- Qualifies machine, feedstock and essential parameters.

- **Part qualification:**

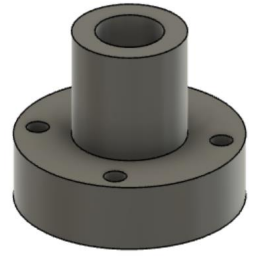
- Sacrificial, prolongation or representative test coupon.
- Qualification of specific parts.

- **Production testing:**

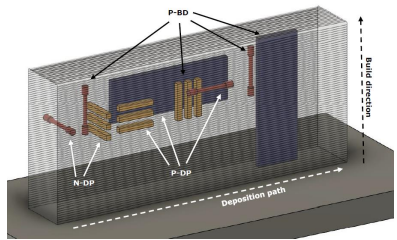
- Test specimens manufactured parallel to relevant parts.
- Verification of build job.



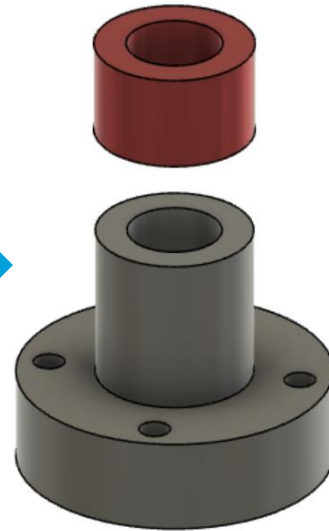
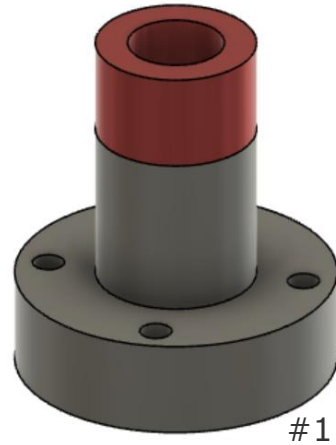
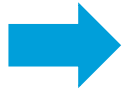
Example of qualification route



AM Category 3



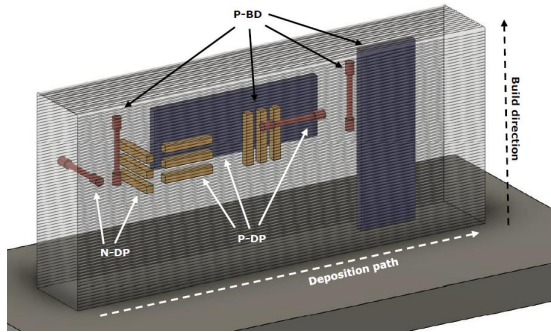
One-time build process qualification



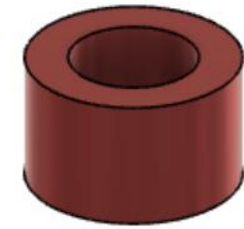
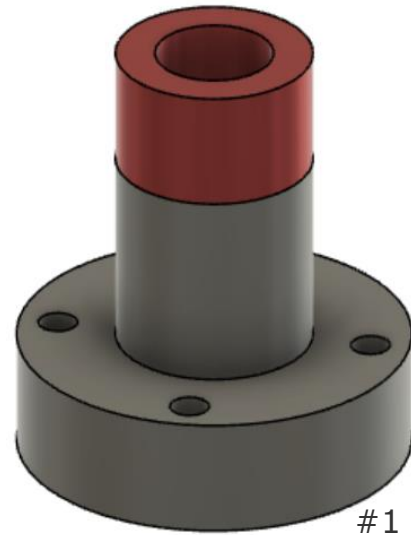
Example of qualification route



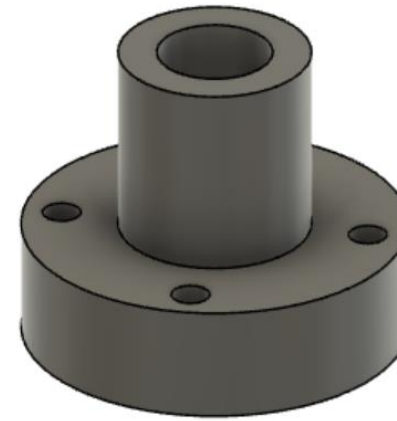
AM Category 2



One-time build process qualification



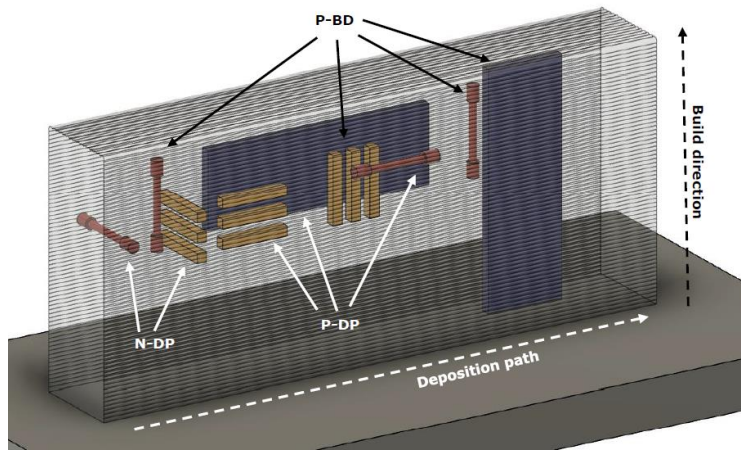
On time part qualification



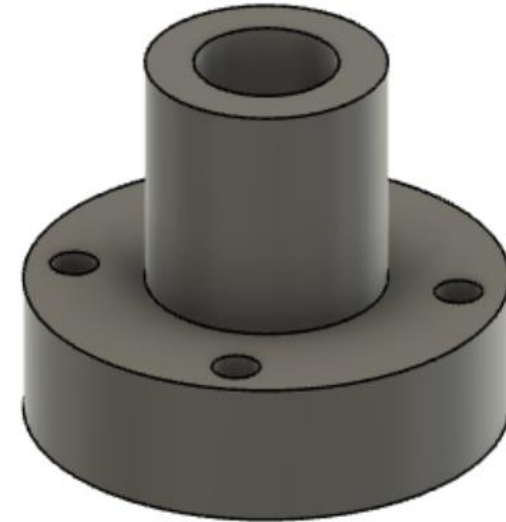
Example of qualification route



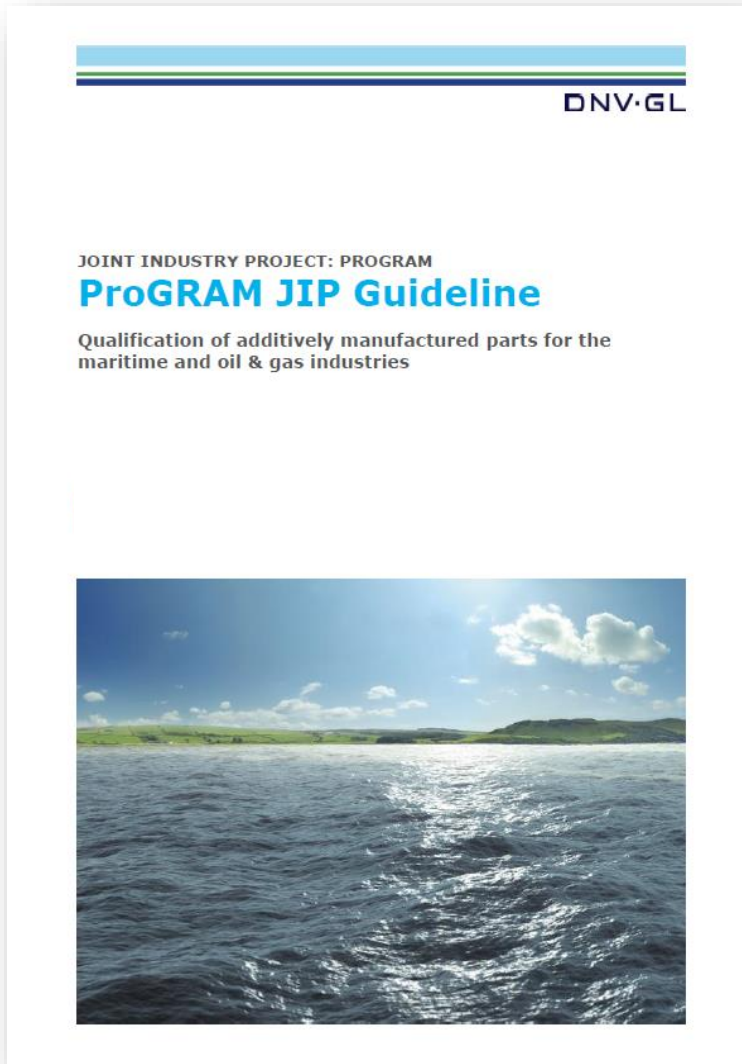
AM Category 1



One-time build process qualification



Use



We are ready to qualify!



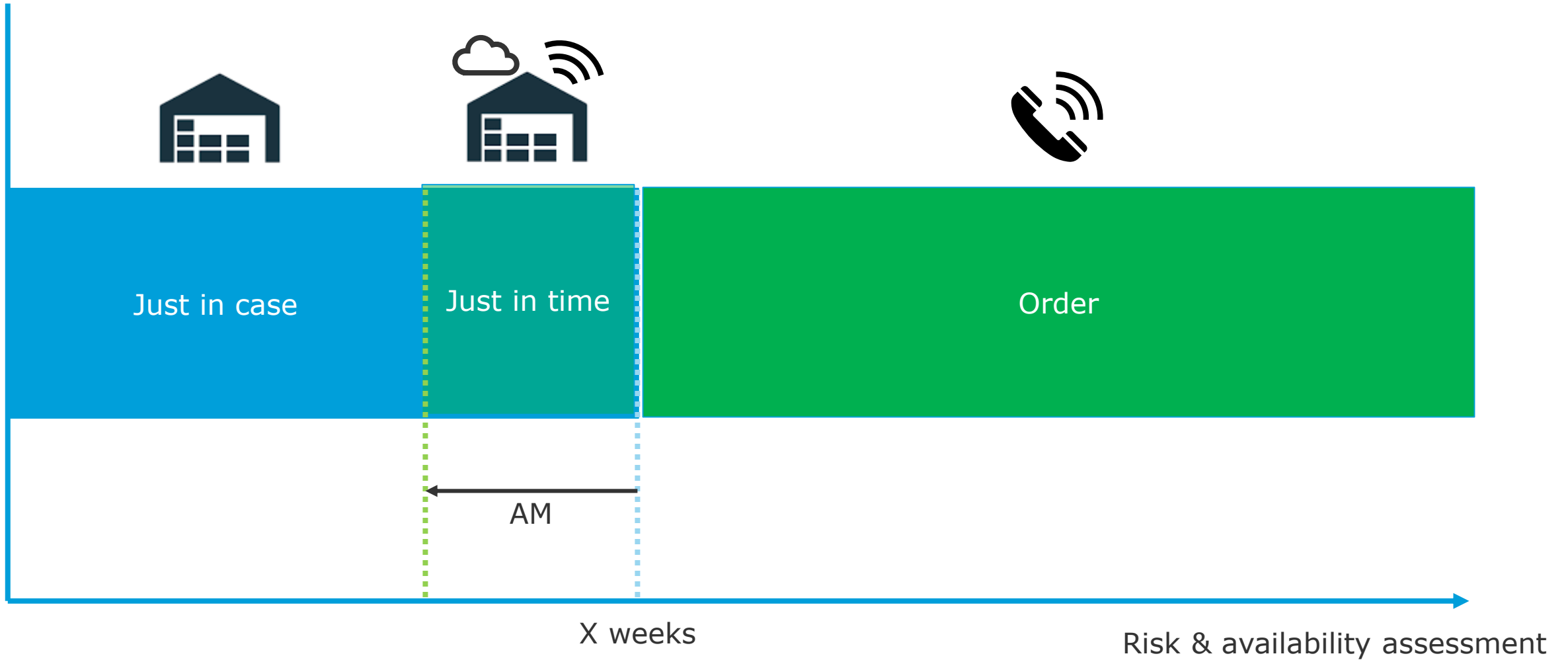
- **Qualification of AM manufacturers**
- **Qualification of AM build process**
- **Qualification of AM parts**

ProGRAM JIP Phase II

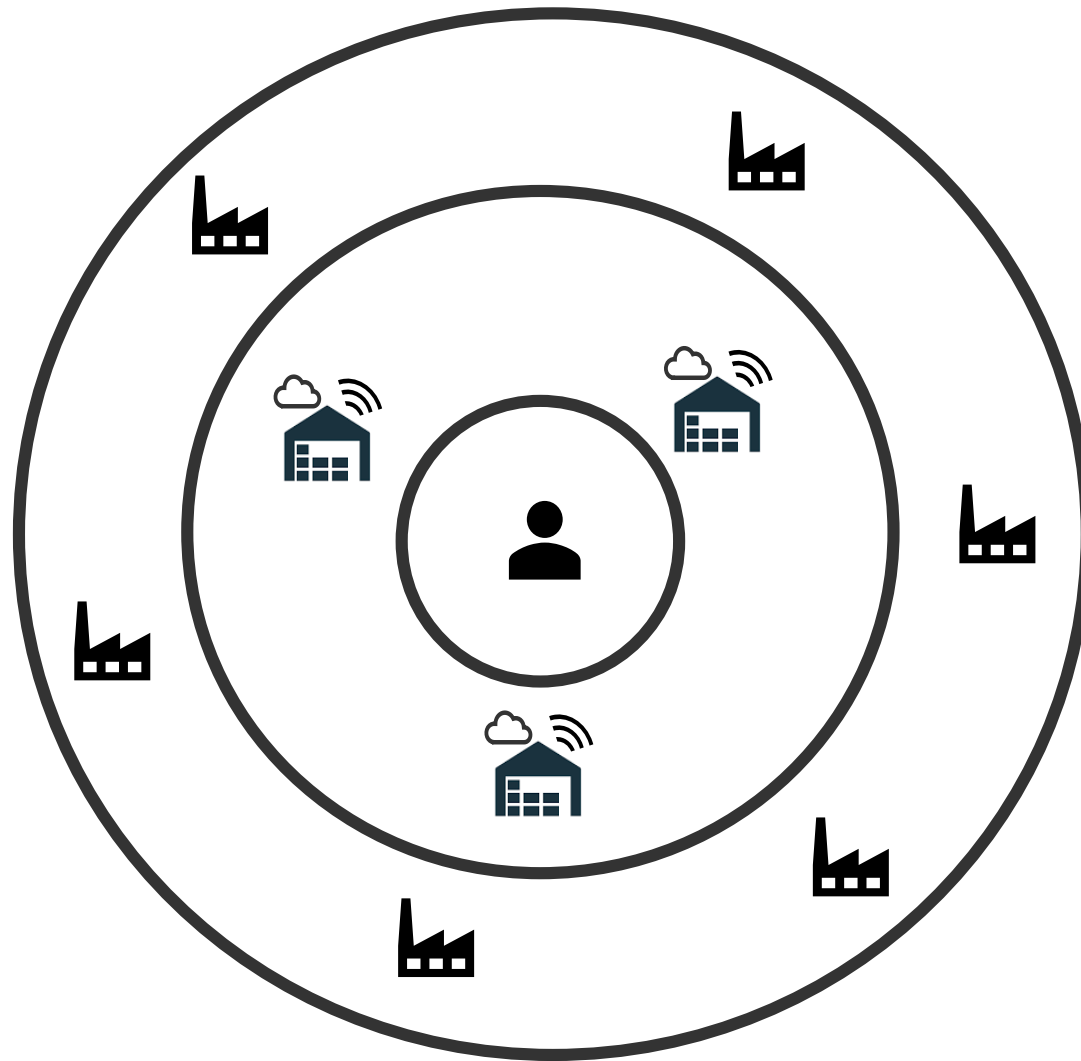
- Continuation of a successful project
- Maturing the requirements from Phase I, and include;
 - WAAM on substrate
 - LMD
 - Binder Jetting
 - PBF-EB
 - Elements of NDT and corrosion
- **Kick off 15th & 16th of April**
 - Confirmed: Equinor, Petrobras, Saudi Aramco, IMI CCI, Kongsberg Maritime
 - Several more interested

Digital Warehouse JIP

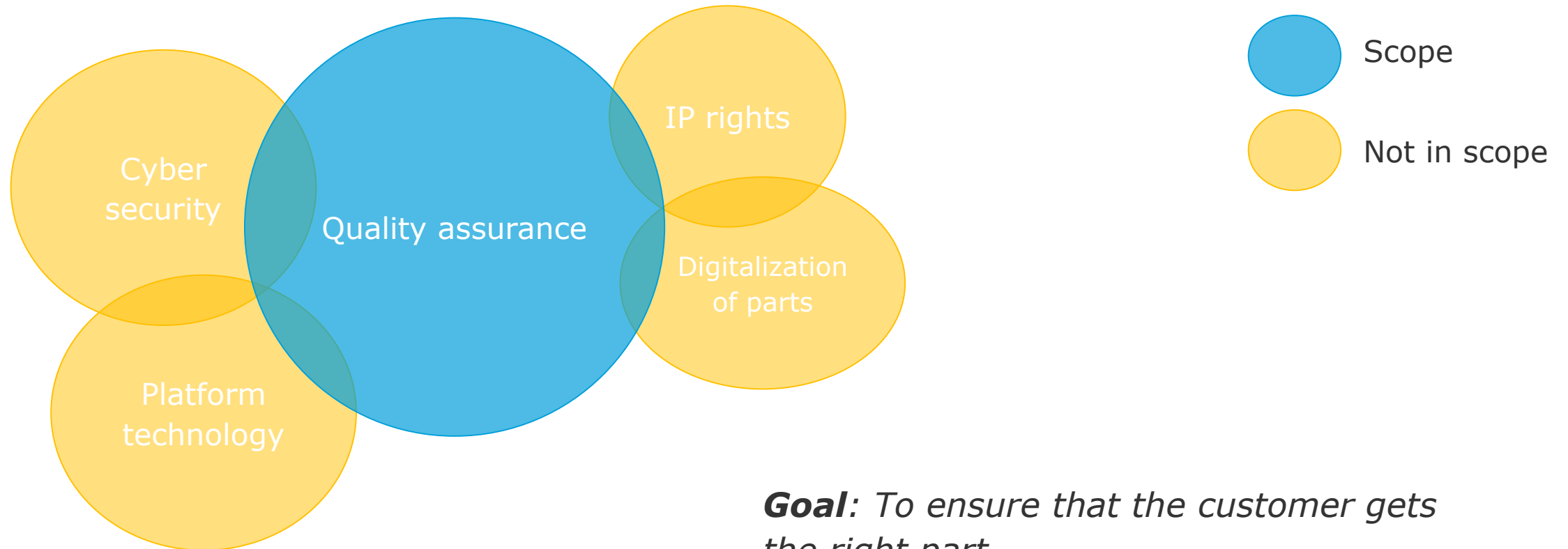
Spare parts in the O&G industry



Novel supply chain / distributed manufacturing



Scope of the JIP



Goal: *To ensure that the customer gets the right part, with the right properties, when requested.*

Key questions to address

How to ensure printing capacity when needed?

How to ensure that the right part is printed?

How to ensure capability of «print shops»?

How do we define «print readiness» of parts?

How do we ensure «print readiness» of parts which have never been printed (first time right)?

How do we account for different risk levels?

What information needs to be available for all parts?

...and on what format?

Objective

Provide an internationally acceptable framework for QA of digital inventory & on-demand printed parts

Provide predictability for the supply chain to reduce cost & lead time

Enable parts, normally stored in a physical warehouse to be stored digitally

Comply with and complement existing industry codes for additive manufacturing

Provide guidance to actors in the value chain (purchasers, manufacturers, platform providers, ...)

Plan

- To be run parallel with ProGRAM JIP Phase II
- **Kick off 15th & 16th of April**
 - Confirmed: Equinor, Petrobras, Saudi Aramco, Siemens, Vallourec, PetroValves, Valland, Immensa Labs, FIT Additive,
 - Several more interested

We are ready to qualify!



- **Qualification of AM manufacturers**
- **Qualification of AM build process**
- **Qualification of AM parts**

Thank you!

Contact information

ole-bjorn.ellingsen.moe@dnvgl.com

+47 476 02 345

www.dnvgl.com

SAFER, SMARTER, GREENER

The trademarks DNV GL®, the Horizon Graphic and Det Norske Veritas® are the properties of companies in the Det Norske Veritas group. All rights reserved