Additive Manufacturing

The path to certification

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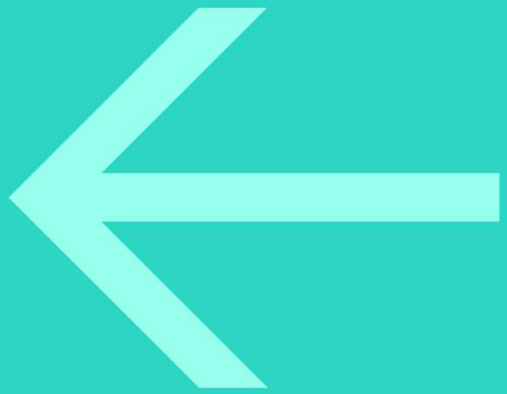
20 March 2019

Lloyd's Register

About Lloyd’s Register

Who are we?



About LR – at a glance

Who we are

A global organisation with specific areas of focus around marine, energy, management systems and inspection services.

History

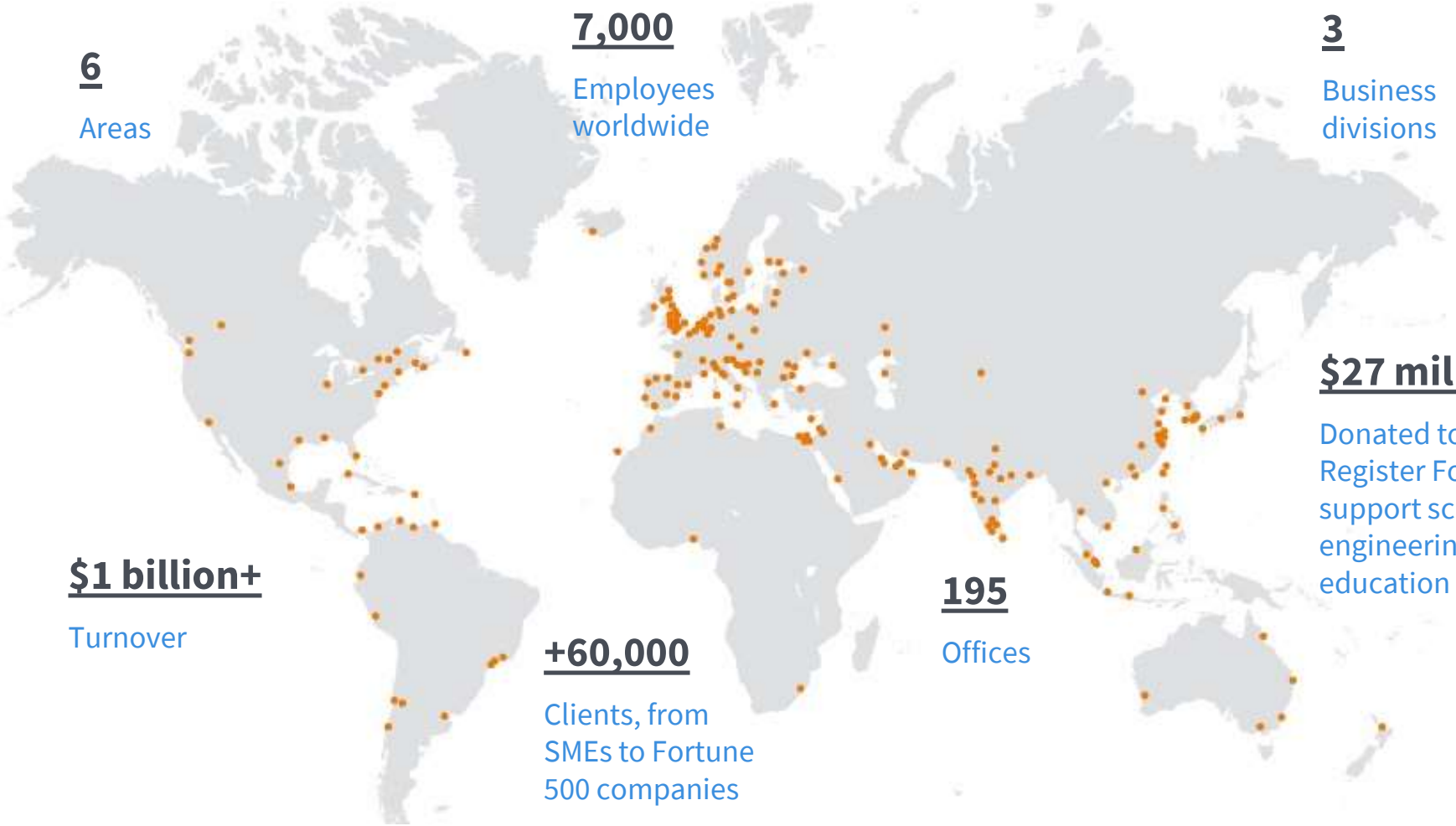
Founded in 1760 as a marine classification society.

Independent

Wholly owned by the Lloyd's Register Foundation, a UK charity dedicated to research and education in science and engineering.

- Mission to enhance safety of life & property, and advance public education
- Based in the UK but awards grants globally
- Impact and excellence are the major grant-giving criteria

About LR



6
Areas

7,000
Employees worldwide

3
Business divisions

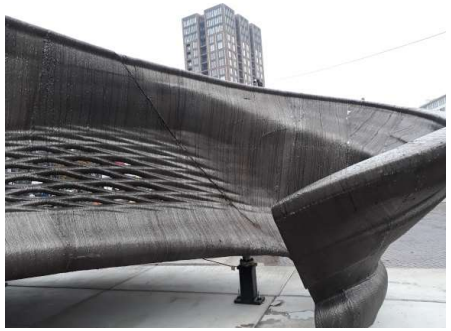
$27 million
Donated to the Lloyd's Register Foundation to support science and engineering research and education

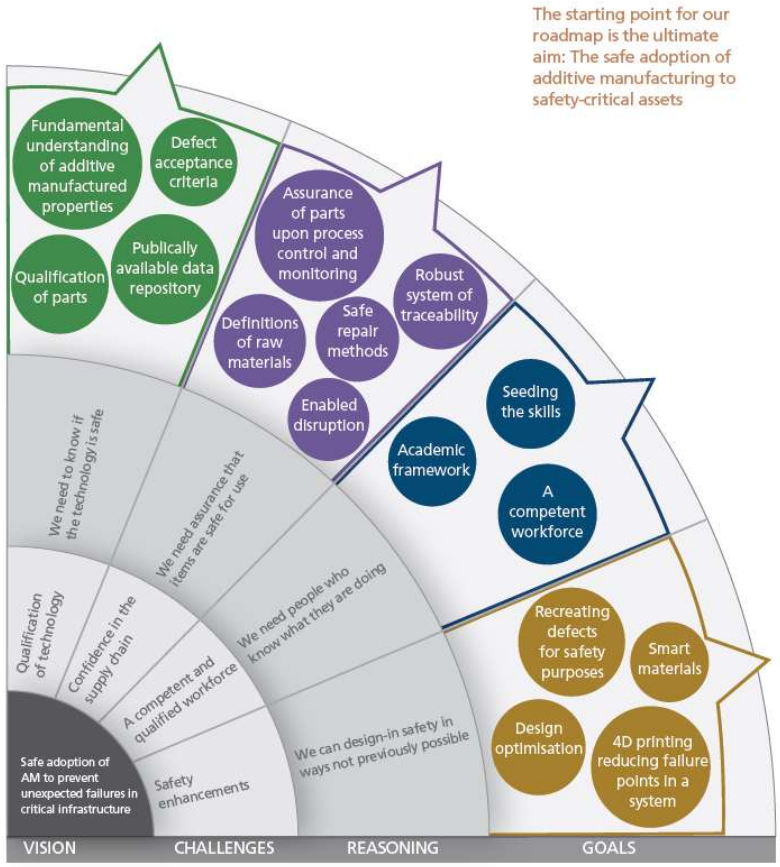
$1 billion+
Turnover

+60,000
Clients, from SMEs to Fortune 500 companies

195
Offices

LR Foundation – Foresight Reviews

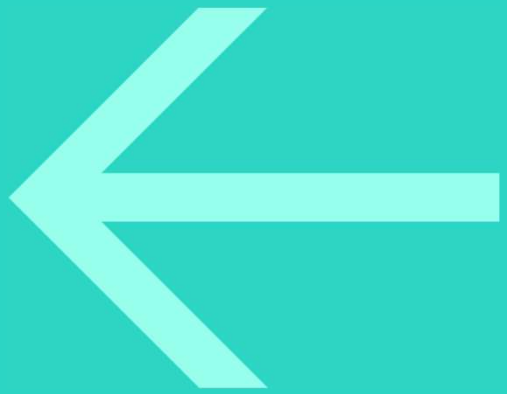




http://www.lrfoundation.org.uk/programmes

Standardisation

The current state of Additive Manufacturing Codes & Standards



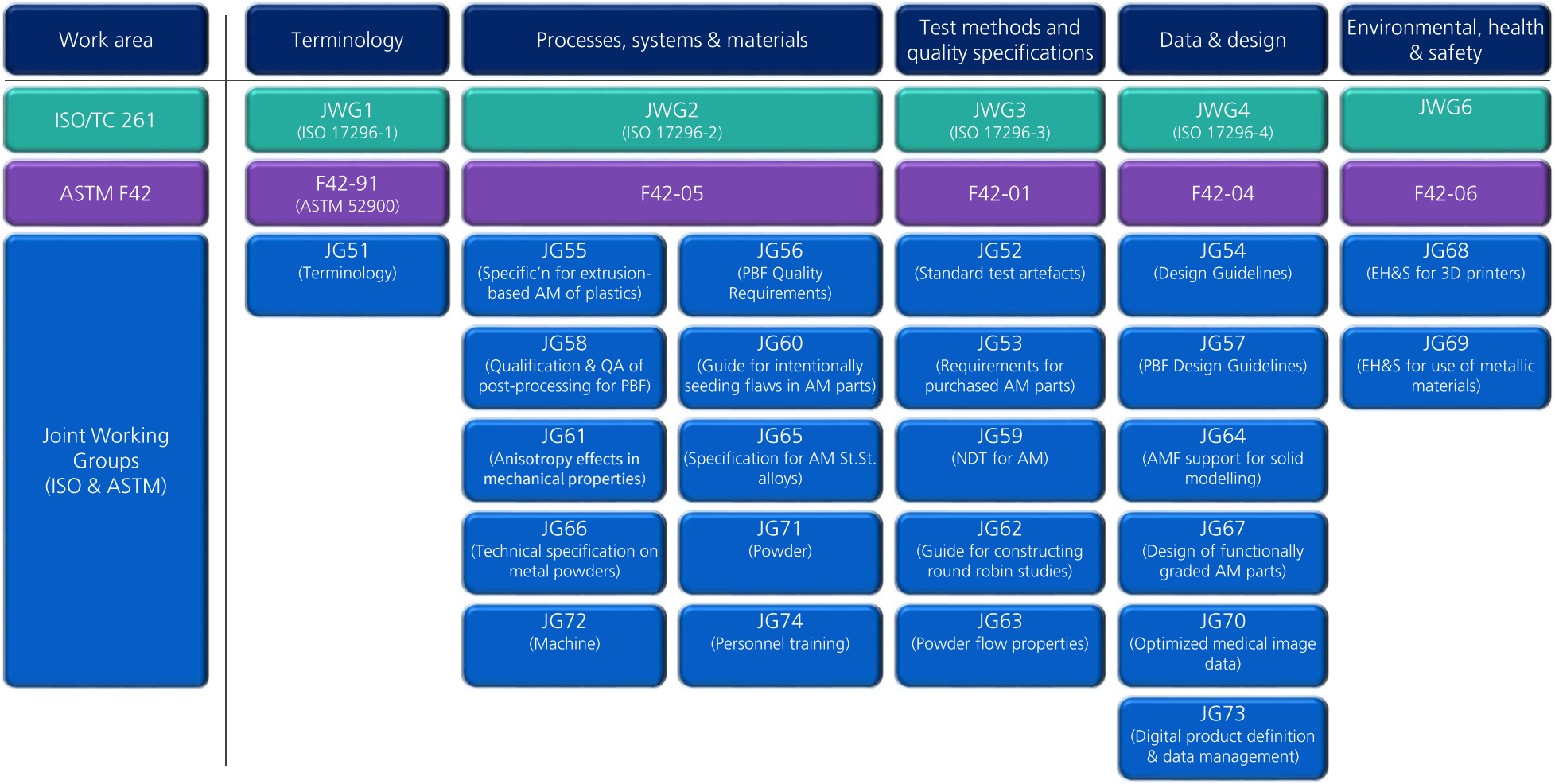
Our authority

Over 60 appointments, certifications, and national approvals from governments, industry groups and accreditation bodies around the world

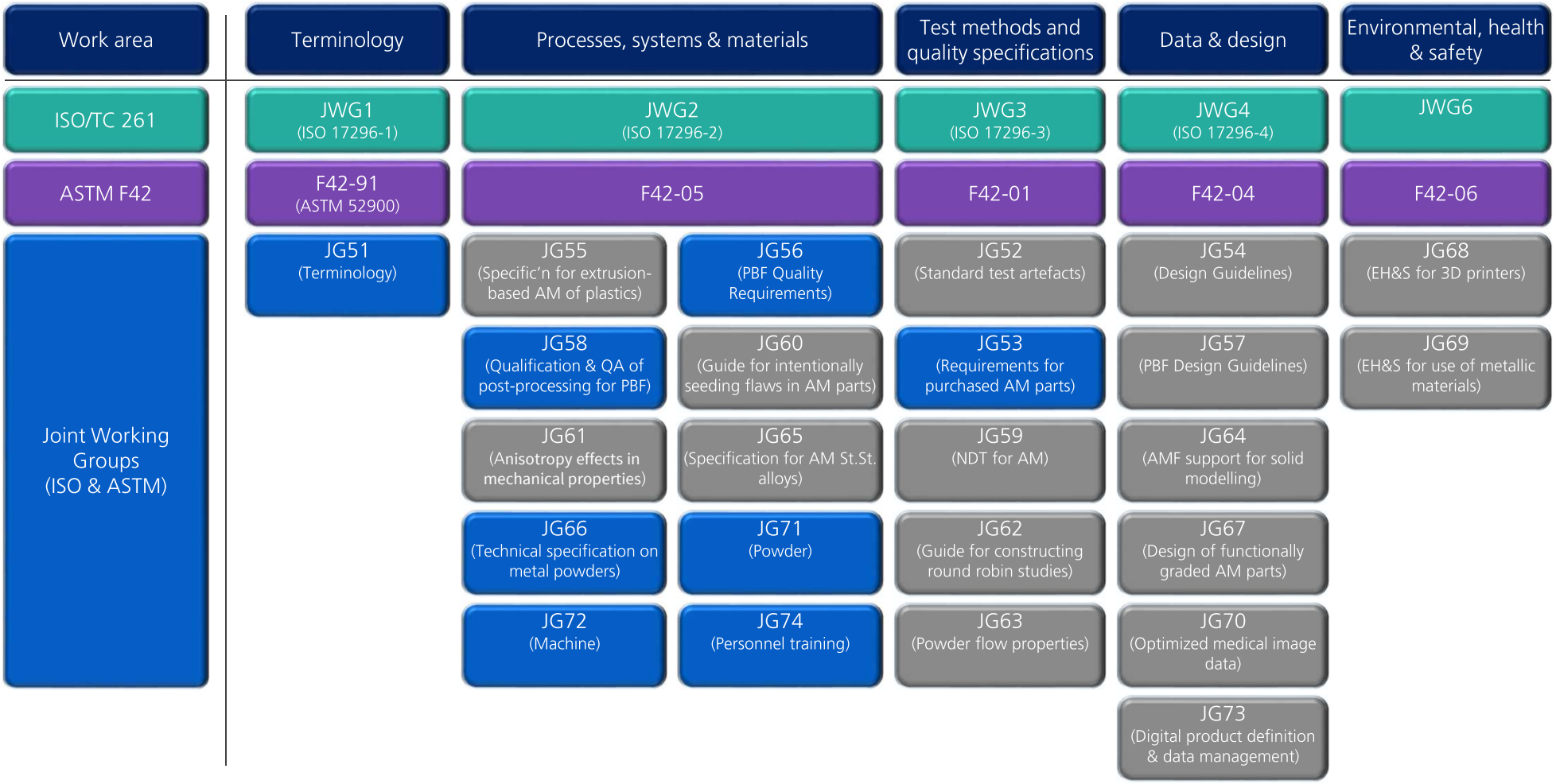
We are members of the following groups:

- ISO/TC261 (Standardization in the field of AM)
- CEN/TC54 (Developing EN 13445-14 for AM in pressure equipment)
- ASME Board on Pressure Technology Codes & Standards Evaluation Of Additive Manufacturing For Pressure Retaining Equipment
- ASME Y14.46 (Product Definition for AM)
- Associazone Italiana Tecnologie Additive (AITA)
- UK National Strategy Group for AM
- French Standard Commission for AM
- Singapore Industrial AM Research Programme Review

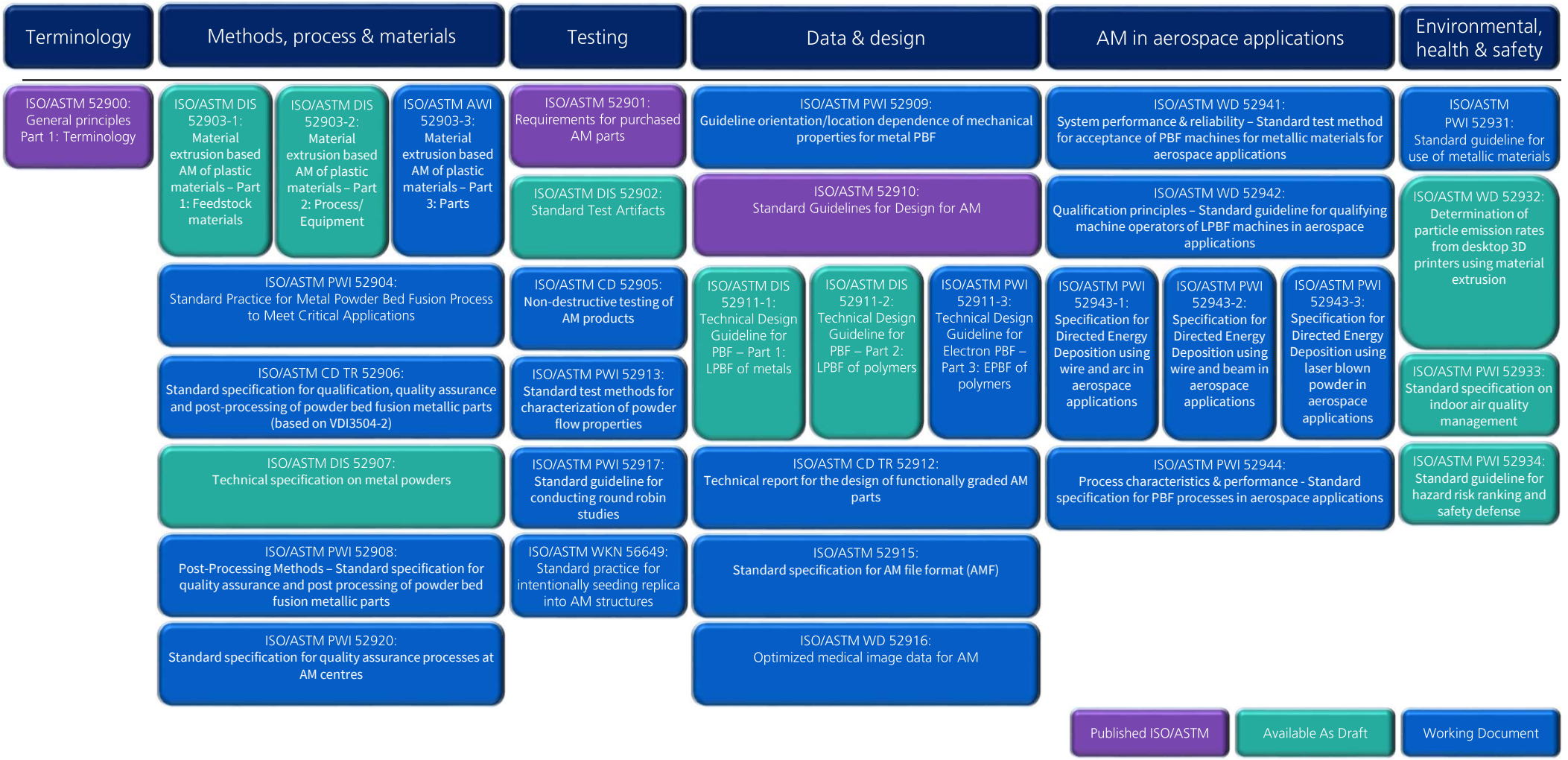
Standardisation: strategy



Standardisation: LR member of these groups



Standardisation: current status



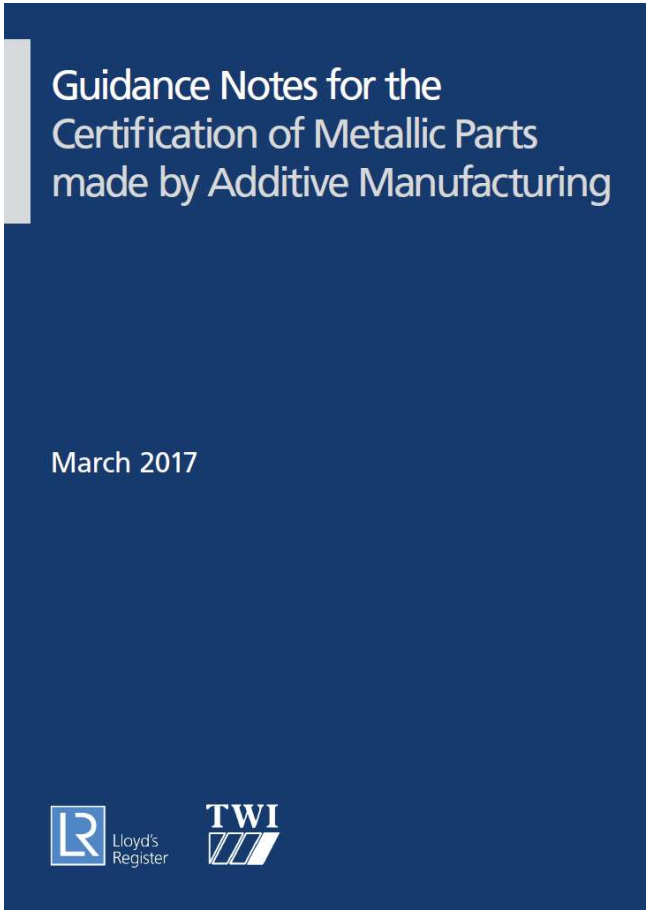
AM material specifications

Designation	Title	Scope
ASTM F2971	Standard practice for reporting data for test specimens prepared by AM	This practice provides a common format for presenting data for AM specimens to establish further data reporting requirements and to provide information for the design of material property databases.
ASTM F3049	Standard guide for characterizing properties of metal powders used for AM processes	Introduces techniques for metal powder characterisation for various powder-based AM processes. It refers to other, existing standards that may be applicable for the characterisation of virgin and used metal powders, processed in AM systems.
ASTM F3122	Standard guide for evaluating mechanical properties of metal materials made via AM processes	This standard serves as a guide to existing standards, or variations of existing standards, that may be applicable to determine specific mechanical properties of materials made with an AM process.
ASTM F2924 (ASTM F3001 is ELI version)	Standard specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium with powder bed fusion	Intended to be used by purchasers or producers, or both, of additively manufactured Ti-6Al-4V components for defining the requirements and ensuring component properties.
ASTM F3055	Standard Specification for Additive Manufacturing Nickel Alloy (UNS N07718) with powder bed fusion	Intended to be used by purchasers or producers, or both, of additively manufactured UNS N07718 components for defining the requirements and ensuring component properties.
ASTM F3056	Standard specification for Additive Manufacturing Nickel Alloy (UNS N06625) with powder bed fusion	Intended to be used by purchasers or producers, or both, of additively manufactured UNS N06625 components for defining the requirements and ensuring component properties.
ASTM F3184	Standard specification for Additive Manufacturing Stainless Steel Alloy (UNS S31603) with powder bed fusion	Intended to be used by purchasers or producers, or both, of additively manufactured UNS S31603 components for defining the requirements and ensuring component properties.
ASTM F3318	Standard for Additive Manufacturing – Finished Part Properties – Specification for AlSi10Mg with Powder Bed Fusion – Laser Beam	Intended to be used by purchasers or producers, or both, of additively manufactured AlSi10Mg parts for defining the requirements and ensuring part properties.

LR-TWI Guidance Notes for AM

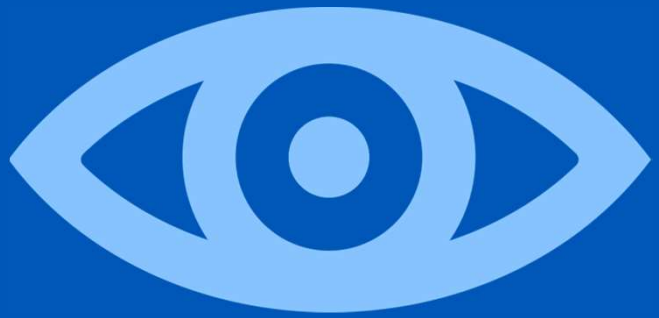
LR & TWI JIP

- The Joint industry project between LR and The Welding Institute (TWI) brings together research and development efforts alongside real-world additive manufacturing practices to develop new industry product certification guidelines - paving the way for more widespread adoption of the additive manufacturing technology.
- ENGIE Lab-Laborelec and Rolls-Royce Nuclear have formally joined the project as sponsors in 2016, supporting the development of both organisations' understanding and certification of additive manufacturing for non-aerospace applications.
- The JIP remains open for additional industry sponsors who will each contribute a detailed component design that will be taken from concept through to completion in the additive manufacturing process.



Achieving certification

The different aspects and relationships between them



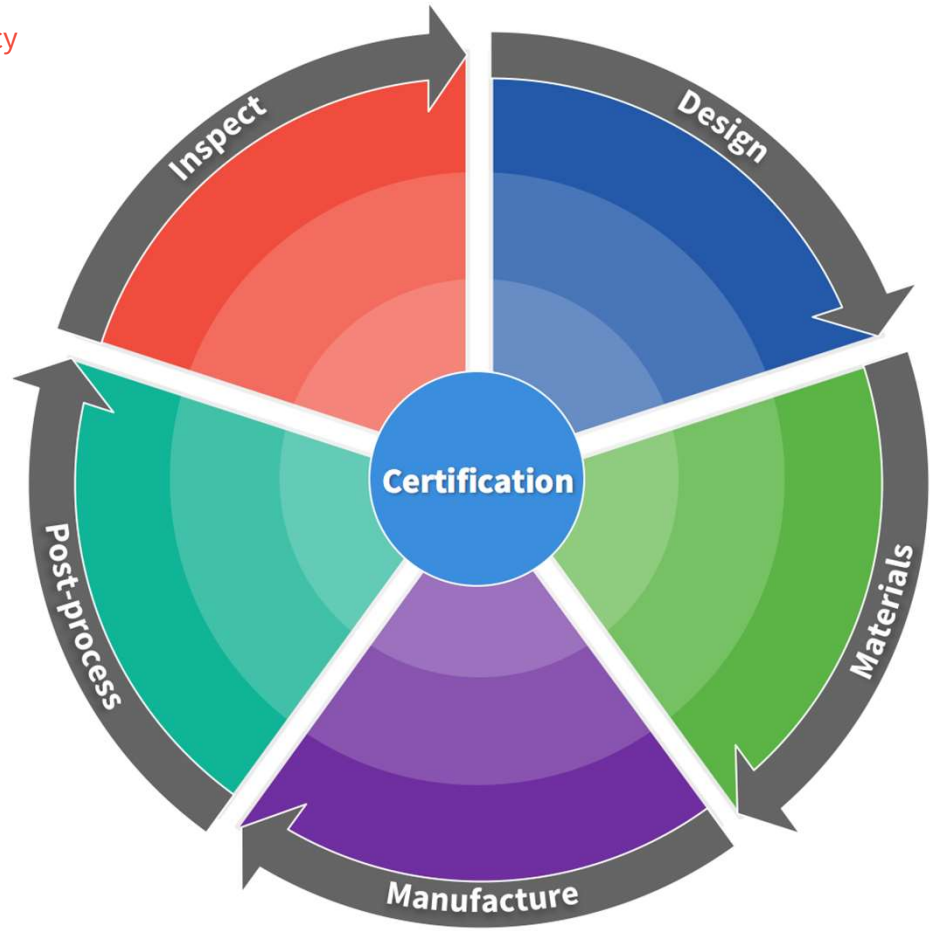
Certification Process

Operator qualifications & competency

Geometric inspection (method depends on complexity of geometry)

Mechanical & metallurgical testing

Destructive/non-destructive testing



Accurate model, translation, offsets

Configuration control, synchronicity between models (e.g. for analysis, manufacture, inspection)

Design for manufacture, for post-processing and for inspection…..

Surface finishing procedures (consistent with test specimens)

Thermal treatments, separation from support structures & build platform

Removal from AM system, cleanliness (i.e. loose powder)

Physical records, control specimens, consistency throughout build

PPE, operator competence, auxiliary systems, work instructions…

Powder production, labelling transportation, storage & handling

Recycling & sampling methods; cleanliness of equipment

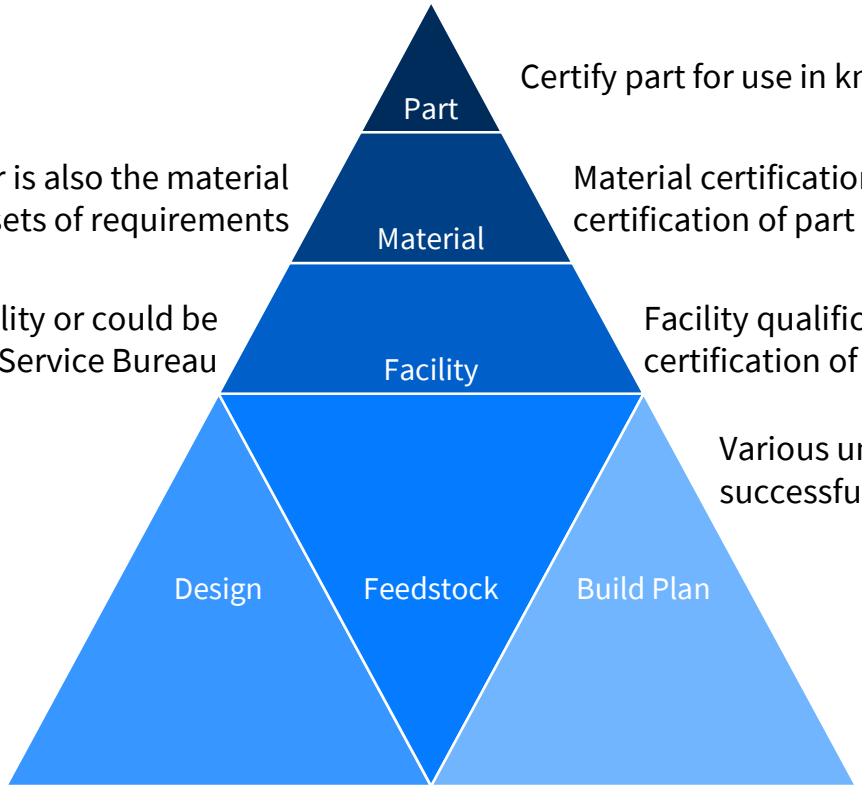
Powder characterisation (i.e. control parameters, test methods, suitability & maintenance of equipment)

Test specimens for formed material testing

Pre-build checks, cleanliness, maintenance of equipment, calibration…

Build control (i.e. parameters, firmware, version control)

Certification Hierarchy



Certify part for use in known application

In AM, the part manufacturer is also the material provider so needs to satisfy both sets of requirements

Material certification is pre-requisite for certification of part

This may be an in-house AM facility or could be sub-contracted to AM Service Bureau

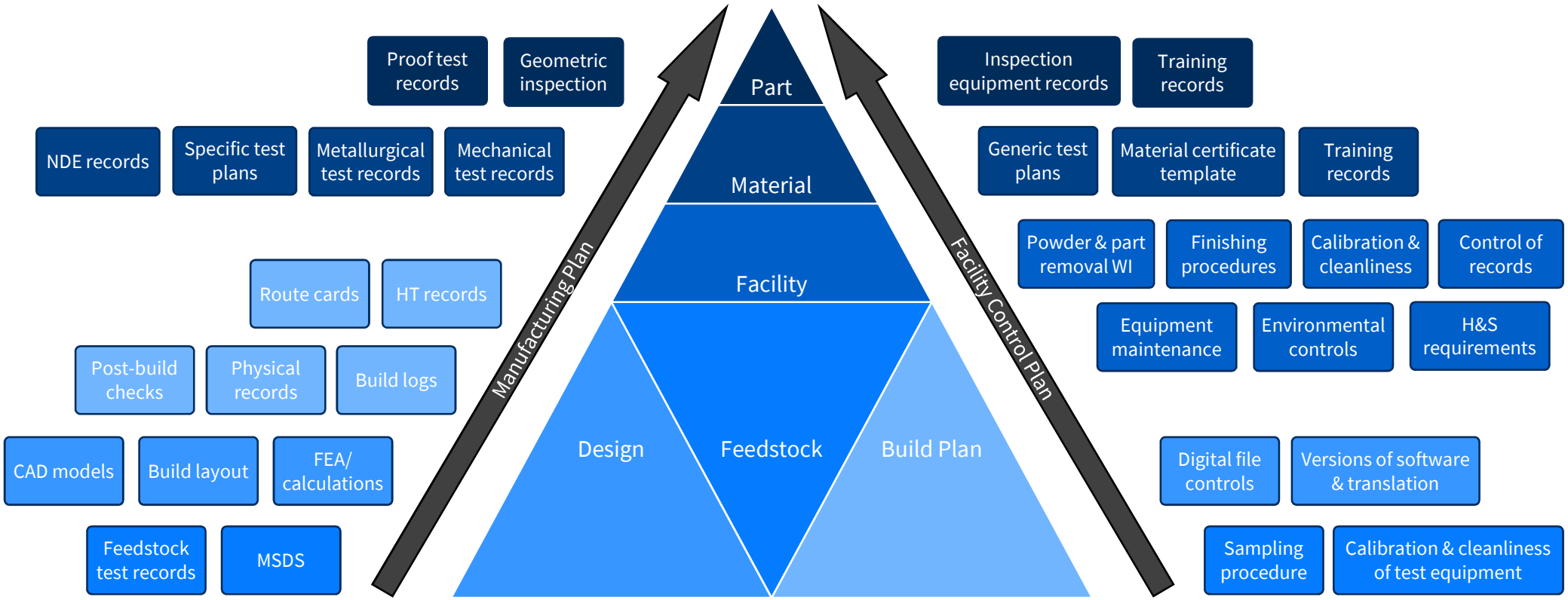
Facility qualification is pre-requisite for certification of part and material

Various under-pinning aspects for successful qualification of the facility

Certification Hierarchy

What is being manufactured
(i.e. specific to the part, almost regardless of facility)

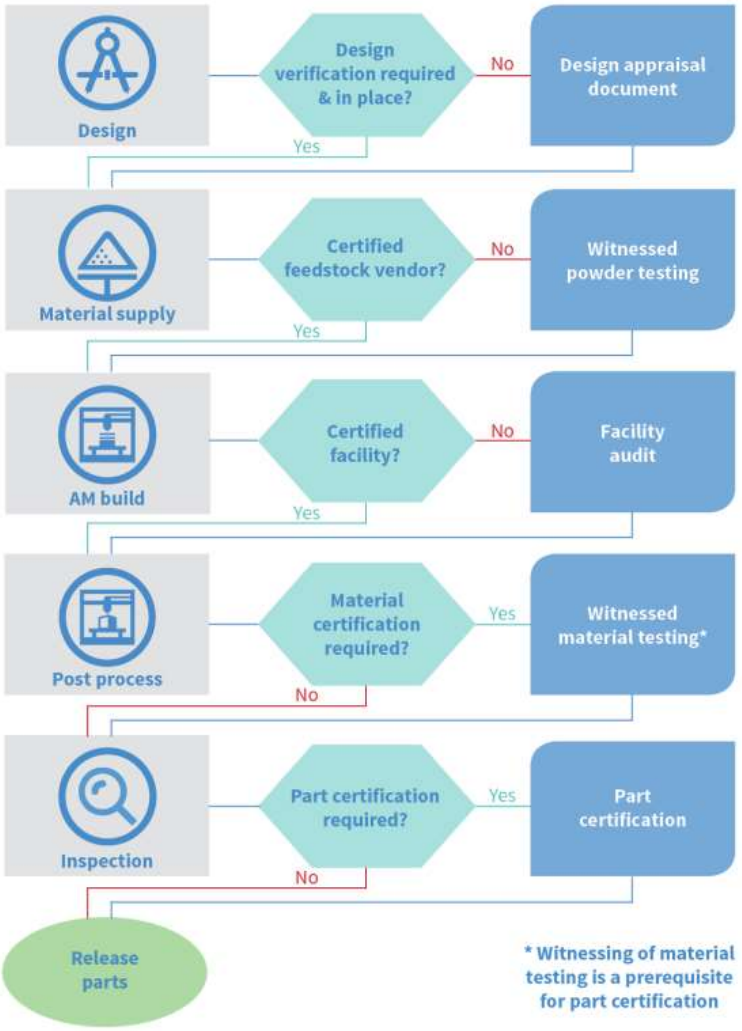
How it's being manufactured
(i.e. specific to the facility, regardless of what is being made)



LR AM certification process

AM component certification SOW

- Design
- Feedstock
- Facility
- Formed material
- Part



About LR's AM services

Our additive manufacturing services

1. Training workshops

- 1-day (for those interested in learning more about AM)
- 2-day (organisations responsible for certification of product and using AM Service Providers)
- 2-day (AM Service Providers that wish to understand more about the certification aspects)
- 3-day (organisations developing in-house AM facilities & responsible for certification of products)

2. Facility Qualification

- Facility audit includes reviewing these aspects:
  - Feedstock receipt, handling & storage
  - Process/AM build control and personnel competence
  - Post-processing & inspection processes & controls
  - Health, safety & environmental considerations
  - Control of non-conforming items (corrective & preventative actions)
- Issue AM Quality Scheme Approval Certificate

3. Material certification

- Feedstock (e.g. powder, wire) certification, which includes witnessed powder characterization testing & assessment against material specification requirements
- Witness formed material testing, using existing inspection methods & issue Inspection Report

4. Part Certification

- Specific to to the design, material, facility & manufacturing instructions used
- Changes to any part of the process would require re-validation of the part certification

An Additive Manufacturing Milestone

The first industrial certified component for Oil & Gas

An Industry First

Project Overview

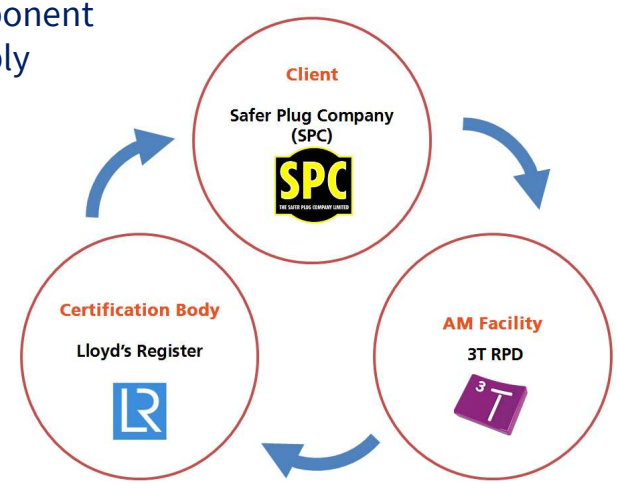
- Titanium gateway manifold for pipelines design by UK-based Safer Plug Company (SPC)
  - Built by 3T RPD using powder bed fusion
  - To be included in an assembly for a suite of pipeline isolation tools, which will include the world's smallest tool suitable for six-inch diameter pipework.
  - Certified in accordance with API 6D and LR Additive Manufacturing Guidance notes
  - LR to certify the next 10 manifolds
  - SPC working now towards Type Approval for on-demand printing

"In taking on this initiative, LR's Additive Manufacturing group has truly opened a gateway to the future"

Ciaran Early, SPC Technical Director

6” Gateway Manifold Project - Summary

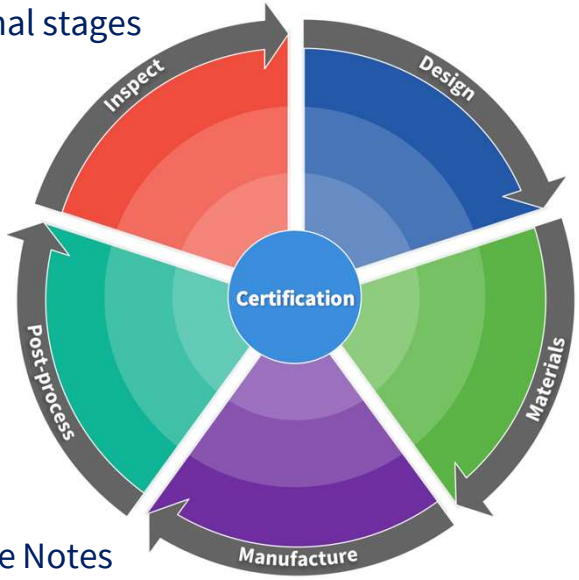
The gateway manifold is a single component within a pipeline isolation tool assembly

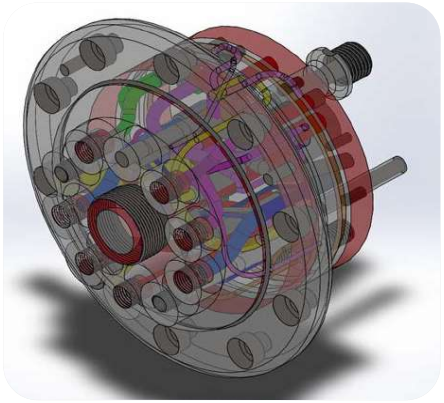


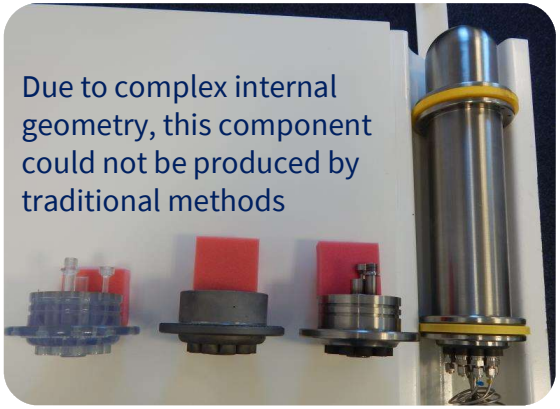
Method:
Powder Bed Fusion

Material:
Titanium (Ti-6Al-4V)

Technology Qualification approach through the five functional stages







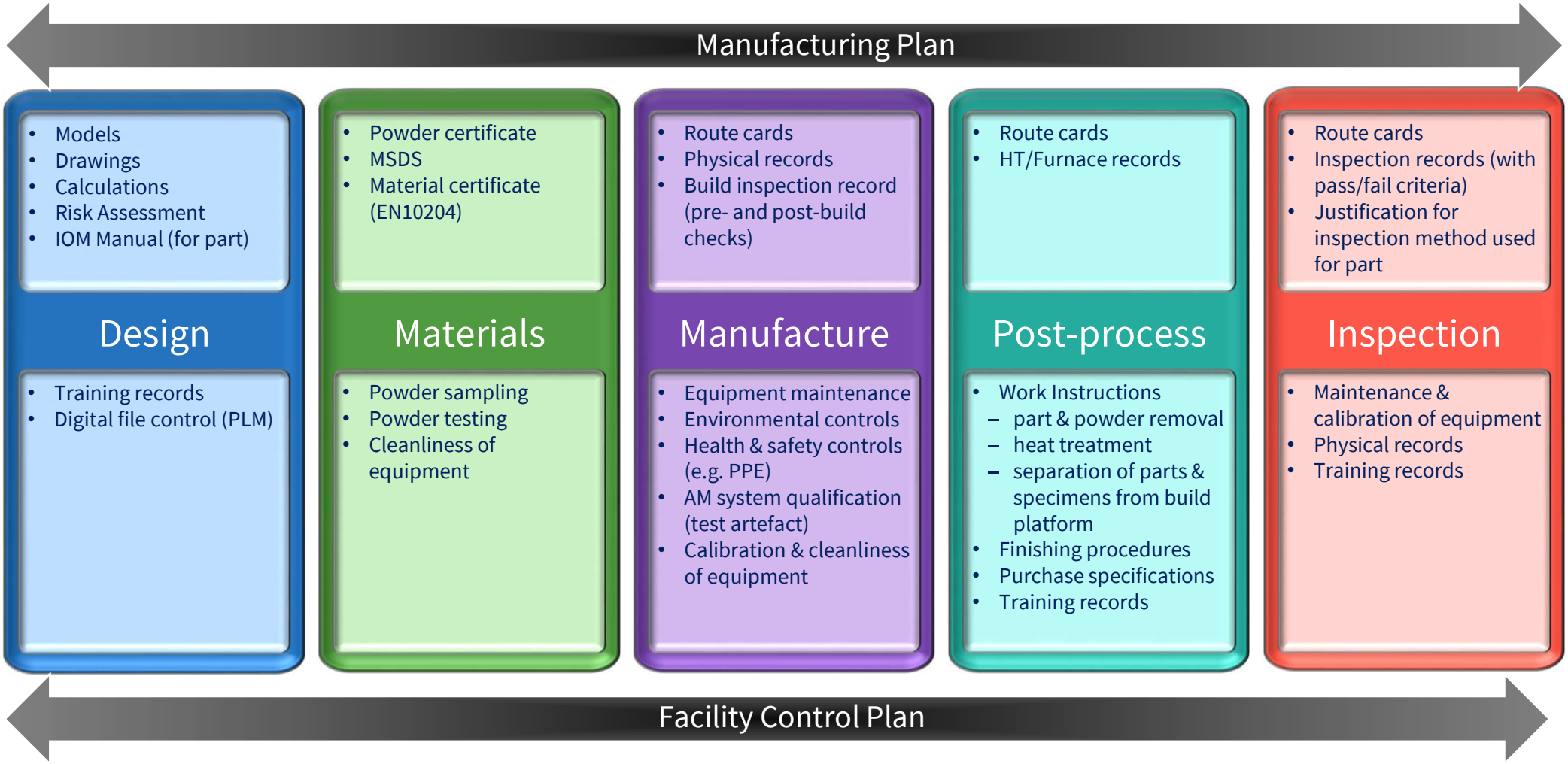
Specifications:

- SPC Technology Qualification Plan
- LR and TWI Guidance Notes for the Certification of Metallic Parts made by Additive Manufacturing
- ASTM F2924-14: Standard Specification for Additive Manufacturing Ti-6Al-4V with Powder Bed Fusion

Certification Process - Typical Project Stages

Stage	Objectives	Deliverables	Client	AM Facility	LR
Kick off meeting	• Define project certification requirements • Agree timescales	• Meeting minutes	• Attendance	• Attendance	• Lead meeting
Design (includes build layout)	• Confirm design complies with the required standards and regulations • Confirm build layouts will provide sufficient specimens for testing	• Design Appraisal Document (DAD) • Statement of Endorsement (if not included within DAD)	• Provide design submission documents • Receive & retain DAD	• Finalise & provide build platform layouts (annotated with sizes)	• Perform design appraisal and endorse build layouts
Materials (powder characterisation)	• Confirm powder meets purchase/material specification	• Conforming powder • LR powder visit report	• Provide purchase / material specification • Receive & retain report	• Source powder • Complete and/or subcontract testing	• Witness powder testing • Review results against material specification
Manufacturing (facility audit)	• Confirm facility capability & quality controls	• Facility audit report	• Receive & retain audit report	• Provision of access to facility & required documentation	• Carry out audit and issue report
Manufacturing (build)	• Produce component and specimens as per build platform layout	• Built part and specimens • Manufacturing Plan	• Compile Manufacturing Plan	• Produce part and record build details	• N/A
Post-processing	• Heat treatment • Removal from build platform • Surface finishing	• Finished part • Test specimens • Traceability specimens • Reviewed heat treatment records	• Receive reviewed heat treatment charts	• Complete and/or subcontract post-processing work	• Review heat treatment documentation
Inspection	• Confirm mechanical & metallurgical properties of component material • Confirm geometrical accuracy of component against CAD model • Perform required proof testing	• Witnessed / reviewed test reports • Results to support certification	• Receive & retain endorsed test reports	• Complete and/or subcontract testing	• Witness testing, review and endorse reports, analysis data for acceptance
Manufacturing record	• Record of manufacturing controls and results	• Complete and endorsed Manufacturing Plan	• Compile Manufacturing Plan	• Provide documentation for Manufacturing Plan	• Review and endorse Manufacturing Plan
Certification	• Certification to confirm acceptance of part	• LR Certificate (Type Approval, Inspection, Validation or Regulatory, as per requirement)	• Receive final part and certification	• N/A	• Provide certification

Certification Process - Documentation



Get in touch

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