Title	**Demonstrate knowledge of additive manufacturing technology**		
Level	**3**	**Credits**	**5**

Purpose	This unit standard is intended primarily for use in training people in industries using additive manufacturing processes, and covers the principles of 3D forming, development, and printing. People credited with this unit standard are able to demonstrate knowledge of: the terminology associated with additive manufacturing technology; different types of additive manufacturing; 3D printing process and compare with conventional manufacturing processes, different types of file formats used in additive manufacturing; basic 3D forming and development techniques; emerging technology and developments in additive manufacturing and how this impacts on an industry sector; dimensional accuracy in 3D printing; and hazards associated with 3D printing.

Classification	Manufacturing Skills > Additive Manufacturing

Available grade	Achieved

Guidance Information

1 References and legislation
ISO/ASTM 52900-15, Standard Terminology for Additive Manufacturing – General Principles – Terminology.
ISO/ASTM 52915-16, Standard Specification for Additive Manufacturing File Format (AMF) Version 1.2.
ISO 1101:2017, Geometrical product specifications (GPS) – Geometrical tolerancing -- Tolerances of form, orientation, location and run-out.
Chua, C. K., Leong, K. F. 2015. 3D printing and additive manufacturing: Principles and applications. 4th Edition. Singapore: World Scientific Publishing Co. Pte. Ltd. ISBN 978-9814571418.
Gidson, I., Rosen, D., Stucker, B. 2015. Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing. Second edition. New York: Springer Science+Business Media. ISBN 978-1-4939-2113-3.
Redwood, B., Schoffer, F., Gorret, B. 2017. The 3D printing handbook: Technologies, design and applications, 1st edition. Amsterdam: Coers and Roest. ISBN978-90-827485-0-5.

2 Definitions
Additive Manufacturing (AM) – the technologies that build 3D objects by adding layer-upon-layer of material typically from the polymer, metal, and ceramic classes. AM encompasses many technologies such as 3D printing, rapid prototyping (RP), Direct

Digital Manufacturing (DDM), layered manufacturing, and additive fabrication.
3D Printing – an additive manufacturing process that creates a physical object from a digital design – a digital model is turned into a solid three-dimensional physical object.
AMF – additive manufacturing file format.
3D – three dimensional.
CAD – computer-aided design.
CAE – computer-aided Engineering.
CAM – computer-aided manufacturing.
CNC – computer numerical control.
CT – computed tomography.
DED – direct energy deposition.
DLP – digital-light processing.
DMLS – direct metal laser sintering.
EBM – electron beam melting.
FDM – fused deposition modelling.
GCode – the programming language of a 3D printer. It contains commands to move parts within a printer i.e. It is a language that tells a printer when, where, how to move and how much to extrude throughout the entire print process.
LOM – laminated object manufacturing.
PIM – plastic injection moulding.
PLT – paper lamination technology.
SLA – stereolithography.
SFF – solid freeform fabrication.
SLM – selective laser melting.
SLS – selective laser sintering.
UV – ultraviolet light.
VRML – virtual reality modelling language.

3 Additive manufacturing terminology used in this unit standard must be consistent with the ISO/ASTM standards listed in the references above.

Outcomes and performance criteria

Outcome 1

Demonstrate knowledge of the terminology associated with additive manufacturing technology.

Range additive fabrication, additive layer manufacturing, CAD, CAE, CAM, CNC, CT, AMF, facet, material extrusion, material jetting, PIM, powder bed fusion, prototype tooling, reverse engineering, rapid prototyping, rapid tooling, SFF, sheet lamination, 3D printing, 3D digitizing or scanning, vat photopolymerization.

Performance criteria

1.1 Terminologies associated with additive manufacturing are explained.

Range evidence of at least ten terminologies is required.

Outcome 2

Demonstrate knowledge of the different types of additive manufacturing.

Range includes but is not limited to – material extrusion (FDM), material jetting, binder jetting, sheet lamination (LOM, PLT), vat photo polymerization (SLA, DLP), powder bed fusion (SLS, SLM, EBM), direct energy deposition.

Performance criteria

2.1 The different types of additive manufacturing are described.

Range evidence of a minimum of three types of additive manufacturing is required.

2.2 Applications of the different types of additive manufacturing are described.

Range evidence of a minimum of three types of additive manufacturing is required.

2.3 Additive manufacturing and subtractive manufacturing are compared in terms of the methods used to produce a product.

2.4 Limitations of additive manufacturing processes are described.

Range limitations may include but are not limited to – prototype, model, cost, economies of scale, size of objects, production rate, materials used.

Outcome 3

Demonstrate knowledge of 3D printing process and compare with conventional manufacturing processes.

Performance criteria

3.1 The entire 3D printing process chain from concept to final product is described.

3.2 Different 3D printing technologies are compared.

Range may include but is not limited to – advantages and disadvantages, additive manufacturing processes, materials, multicolour printing capability;
printing methods may include but are not limited to – FDM, SLA, SLS, material jetting, metal printing (DMLS or SLM);
evidence of comparison of two different printing methods is required.

3.3 Key design considerations for 3D printing a product are described.

Range printability, overhang, part/component wall thickness, warping, details.

3.4 The advantages of additive manufacturing over conventional manufacturing processes such as machining and welding are described.

Range reduction of tooling, agile manufacturing operations, decentralized manufacturing, inventory reduction and part consolidation, sustainability (raw material use) and environmental impact, speed of production, single step manufacture, cost (machine operation, material, and labour), risk mitigation, complexity and design freedom, standardization and customization, ease of access, mass customisation;
evidence of a minimum of five advantages is required.

3.5 3D printing is compared with CNC machining in terms of production and quality.

Range turn around times, cost, product quantity, product complexity, materials, product material machinability, product dimensional accuracy, post processing methods;
evidence of a minimum of four comparisons is required.

Outcome 4

Describe the different types of file formats used in additive manufacturing.

Range may include but is not limited to – AMF, STL, GCode, VRML;
evidence of a minimum of two formats is required.

Performance criteria

4.1 File formats used in additive manufacturing are identified.

4.2 The different features of each file format are described.

Outcome 5

Demonstrate knowledge of basic 3D forming and development techniques.

Performance criteria

5.1 The concept of modelling or prototyping using 3D printing and scanning techniques, and how this technology is used for actual manufacturing for production quantities is described.

5.2 Pattern development techniques using 3D printing are described.

5.3 3D processes are described and compared

Range may include but is not limited to: production cost, economies of scale, size restrictions, speed of process and throughput, ease of use, materials, quality assurance, digital inventories, on-demand manufacturing;
3D processes may include but is not limited to: SLA, DLP, FDM, SLS, SLM, EBM, LOM;
evidence of two 3D processes are required.

Outcome 6

Demonstrate knowledge of emerging technology and developments in additive manufacturing and how this impacts on an industry sector.

Performance criteria

6.1 Trends and emerging technology in additive manufacturing and impacts on an industry sector are described.

Range industry sectors include but are not limited to – aerospace, medical, dental, consumer goods, mechanical equipment and tools, automotive, marine, defence;
evidence of one industry sector is required.

Outcome 7

Demonstrate knowledge of dimensional accuracy in 3D printing.

Performance criteria

7.1 The factors that determine whether a part will print to specifications are described.

Range design, materials.

7.2 The accuracy of the 3D printed parts produced by various 3D printing methods is compared.

Range parameters used as accuracy variables may include but are not limited to – dimensional accuracy, warping or shrinkage, support requirements;
printing methods may include but are not limited to – FDM, SLA, SLS, material jetting, metal printing (DMLS or SLM);
evidence of comparison of two different printing methods is required.

Outcome 8

Demonstrate knowledge of hazards associated with 3D printing.

Performance criteria

8.1 The hazards associated with 3D printing and its management are described.

Range hazards may include but are not limited to – hazards associated with electrical shock, electromechanical force, UV, laser beams; burns from molten materials; health hazards associated with inhalation of ultrafine and/or toxic smoke, fumes, and dusts; evidence of four hazards is required.

Planned review date	31 December 2023

Status information and last date for assessment for superseded versions

Process	Version	Date	Last Date for Assessment
Registration	1	26 July 2018	N/A

Consent and Moderation Requirements (CMR) reference	0013

This CMR can be accessed at http://www.nzqa.govt.nz/framework/search/index.do.

Comments on this unit standard

Please contact Competenz qualifications@competenz.org.nz if you wish to suggest changes to the content of this unit standard.