SECTOR SKILLS STRATEGY IN ADDITIVE MANUFACTURING

Co-funded by the Erasmus+ Programme of the European Union

Project No. 601217-EPP-1-2018-1-BE-EPPKA2-SSA-B

CU 36: Coordinating the AM Process (Pilot)

TOPIC 5: Quality systems & Quality Control Documentation

David Wimpenny (MTC)

FOR SAM PILOT ATTENDEES AND TRAINERS ONLY

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Topics covered include…

- Quality & quality management
- Quality management systems
- How QMS can be applied within a AM activity
- ISO9001
- Certification / registration
- Kanban boards & cards
- Total quality management

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Quality & Quality management

- Quality must reflect all the features of a product (or service) which are required by the customer.
- Quality management is what the organization does to;
  - ensure that its products or services satisfy the customer's quality requirements

  and
  - comply with any regulations applicable to those products or services.

REF: Overview of ISO 9001 and ISO 14001 by Roger Frost e-mail frost@iso.org Manager, Communication Services2009-01-08

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Quality Management System (QMS)

By systemizing quality management;

- Nothing important is left out.
- Everyone is clear about who is responsible for doing what, when, how, why and where.
- Management system **standards** provide the organization with an international, state-of-the-art model to follow.

REF: Overview of ISO 9001 and ISO 14001 by Roger Frost e-mail frost@iso.org Manager, Communication Services2009-01-08

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What is a Quality Management Systems?

Includes;

- Policies
- Procedures
- Plans
- Resources
- Processes
- Practices

…. specification of responsibilities and authority of an organization designed to achieve product and service quality levels, customer satisfaction and company objectives.

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Quality Management Systems (QMS) systems: Relevant Sector Standards/ Accreditations

ISO 9001 - quality management system industry generic

AS 9100 – quality management system for aviation space and defence

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Processes, not products

QMS standards concern the way an organization goes about every aspect of its work;

- Not product standards.
- They are process standards.
- Can be used by product manufacturers and service providers.

REF: Overview of ISO 9001 and ISO 14001 by Roger Frost e-mail frost@iso.org Manager, Communication Services2009-01-08

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Principles of the ISO 9001 Standard

1. **Customer Focus** – understand needs, meet requirements, exceed expectations

2. **Leadership** – unity of purpose, organizational direction, empowerment, achieve objectives

3. **Involvement of People** – fully involved employees, to benefit the organization

4. **Process Approach** – accomplishments by processes, resources must be managed

Ref:https://www.academia.edu/19670615/Dave_John_Mike_Quality_Management_Systems_PPT_03

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Principles of the ISO 9001 Standard – Cont.

5. **System Approach to Management-** processes managed as system

6. **Continual Improvement** – permanently applied to the organization, its people, their processes, their systems and their products

7. **Factual Approach to Decision Making** – decisions based on analysis of accurate, relevant and reliable data

8. **Mutually Beneficial Supplier relationships** – organization and suppliers benefit from each other's resources and knowledge

Ref:https://www.academia.edu/19670615/Dave_John_Mike_Quality_Management_Systems_PPT_03

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Quality System Documentation Overview

https://advisera.com/9001academy/knowledgebase/how-to-structure-quality-management-system-documentation/

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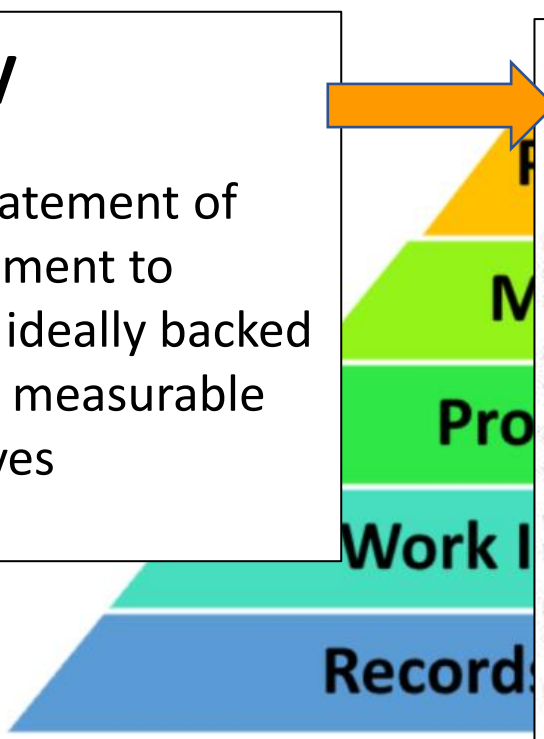
Quality System Documentation Overview

Policy

Clear statement of commitment to quality, ideally backed up with measurable objectives



https://advisera.com/900
quality-management-syste

Protea
technology leadership
in measurement solution

Protea Limited (Protea) is committed to satisfying the requirements of its customers in the areas of analyser systems design, manufacture, supply and servicing, and working at all times in accordance with stated methods, and to a consistently high standard of professional practice.

Protea will deliver a high standard of service and the aim of the Quality System is to ensure that this is consistently achieved.

Protea aims to develop and grow its services and establish, through Management Review, a system for setting and reviewing objectives and to ensure that the IMS is still effective and appropriate.

The Management Team shall ensure the quality policy is communicated and understood by all members of Protea's staff, who will in turn actively support it by taking personal responsibility for their work.

Protea is committed to comply with the requirements of ISO 9001:2015 and BS EN 15267-2:2009 and to respond to the information generated by the IMS to invoke continual improvement.

In addition, Protea Peterborough is committed to comply with the requirements of ISO / IEC 80079-34:2011.

Andrew Toy

Managing Director

Date: 12th February 2018

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Quality System Documentation Overview

Manual

Clearly states the company's intentions for operating the processes within the quality management system. It can include policies for all areas of the business that affect ability to make high quality products and meet customers ar ISO 9001 requirements

https://isoconsultantkuwait.com

https://advisera.com/9001acaden quality-management-system-docu

Quality Manual Contents

- Introduction & Scope
- Quality Management Principles
- References and Definitions
- Context of the Organization
- Leadership
- Management System Planning
- Support
- Operation
- Performance Evaluation
- Improvement
- Appendices

https://www.iso-9001-checklist.co.uk/quality-manual-template-gbp.htm

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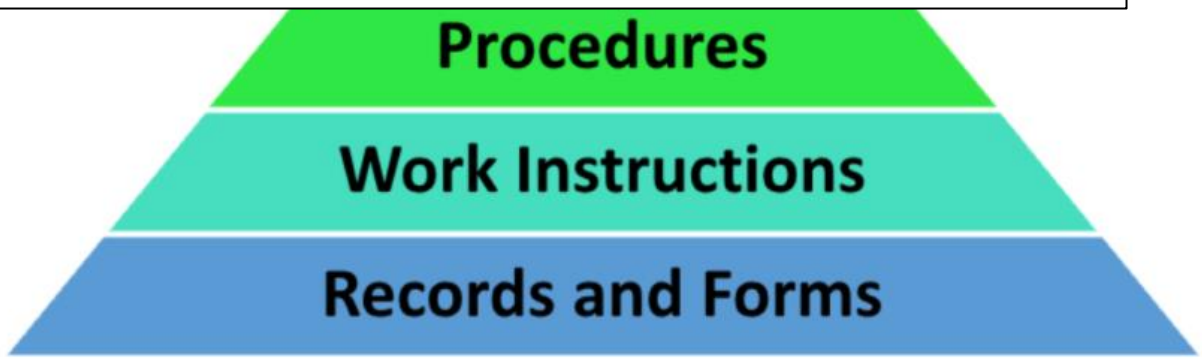
Quality System Documentation Overview

Quality Procedures

Step by step what the company does to meet policy

- Procedure for each ISO principle
- Processes for procedures that affect quality

https://www.iso-9001-checklist.co.uk/quality-manual-template-gbp.htm



https://advisera.com/9001academy/knowledgebase/how-to-structure-quality-management-system-documentation/

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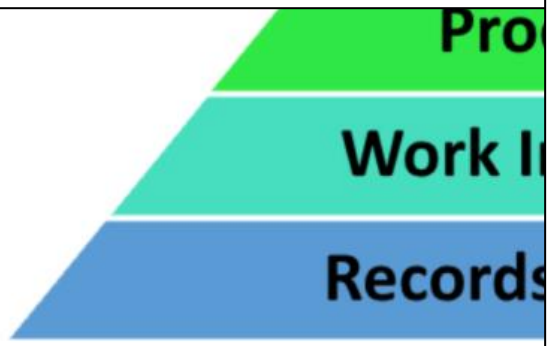
Work Instructions

Document containing detailed instructions that specify exactly what steps to follow to carry out an Activity. A work instruction contains much more detail than a Procedure and is only created if very detailed instructions are needed



https://advisera.com/9001
quality-management-syste

9 "Rules" for work instructions

1. Know exactly how to do the task.
2. Plan how to write steps in order.
3. Write instructions beginning with verb.
4. Write each step as a small piece.
5. Include warnings as pre-steps.
6. Write the steps in logical order.
7. Review and edit instructions carefully.
8. Express steps in the positive.
9. Avoid expressing opinions, preferences, or choices.

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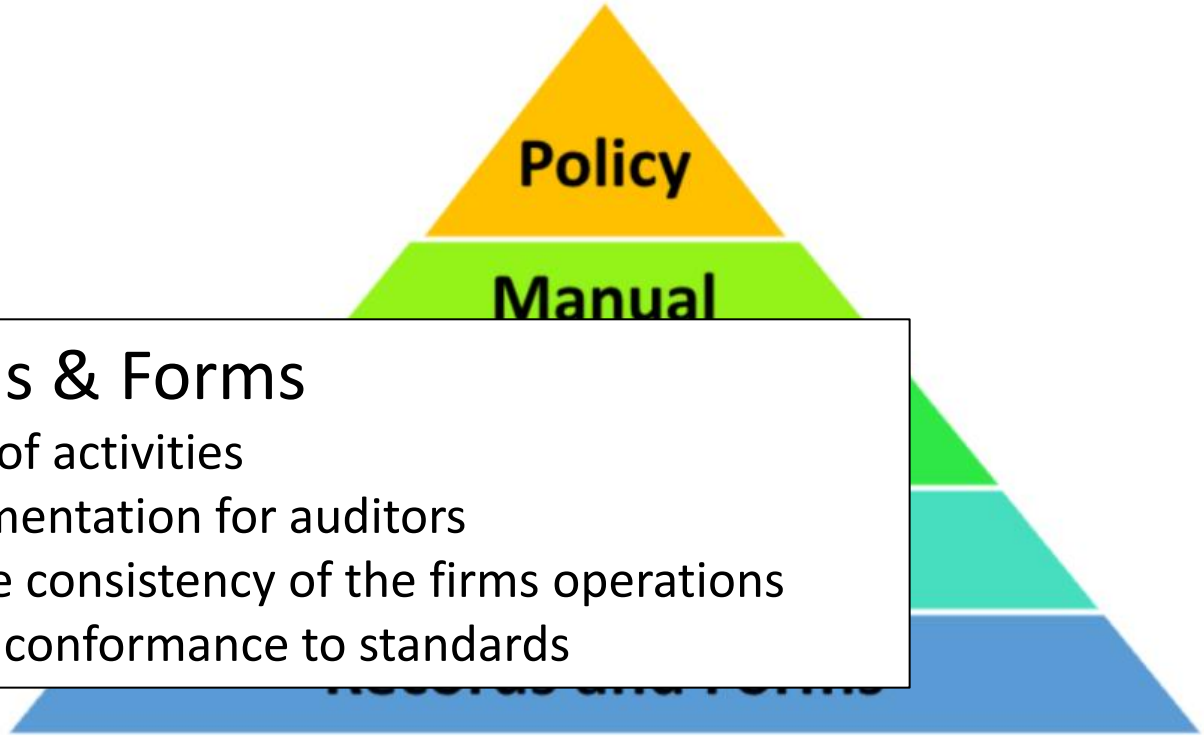
Quality System Documentation Overview



Records & Forms

- Proof of activities
- Documentation for auditors
- Ensure consistency of the firms operations
- Verify conformance to standards

https://advisera.com/9001academy/knowledgebase/how-to-structure-quality-management-system-documentation/

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Certification and registration

- Certification is known in some countries as registration
- Means independent, external body has audited QMS and verified it conforms to requirements of the standard
- Certification gives more credibility in world marketplace

But

- Organisations can implement without spending money on a certification programme but cannot claim to “hold” ISO 9001 without passing an external audit.

Ref:https://www.academia.edu/19670615/Dave_John_Mike_Quality_Management_Systems_PPT_03

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Kanban System

- Devised in 1940s by Taichi Ohno for Toyota
- Expediting the manufacturing processes through continuous improvement.
- remove obstacles and keeping team communication clear by standardizing and refining the processes.
- This further helped in waste reduction and ultimately, maximized value.
- Kanban forms a critical part of Lean Thinking

https://productivityland.com/what-is-kanban-board/

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Kanban is really about improved visualisation

- Visualise work
- Limit work in progress
- Manage flow
- Make policies explicit
- Implement feedback loops
- Improve collaboratively, evolve experimentally

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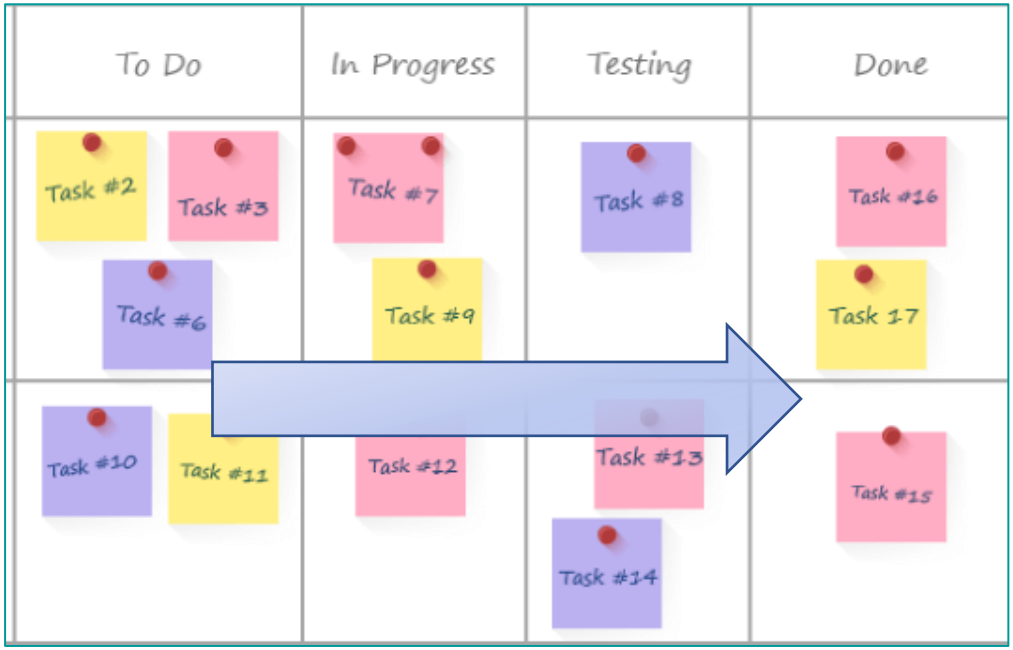
Kanban Board

- Columns represent workflow stages
- Cards move left to right across horizontal “swimlanes”
- Easy visualization of project status



https://productivityland.com/what-is-kanban-board/

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Physical Kanban board and cards

https://tcardsdirect.co.uk/

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Computer generated Kanban board

https://blog.planview.com/8-kanban-board-examples-for-engineering-manufacturing-organizations/

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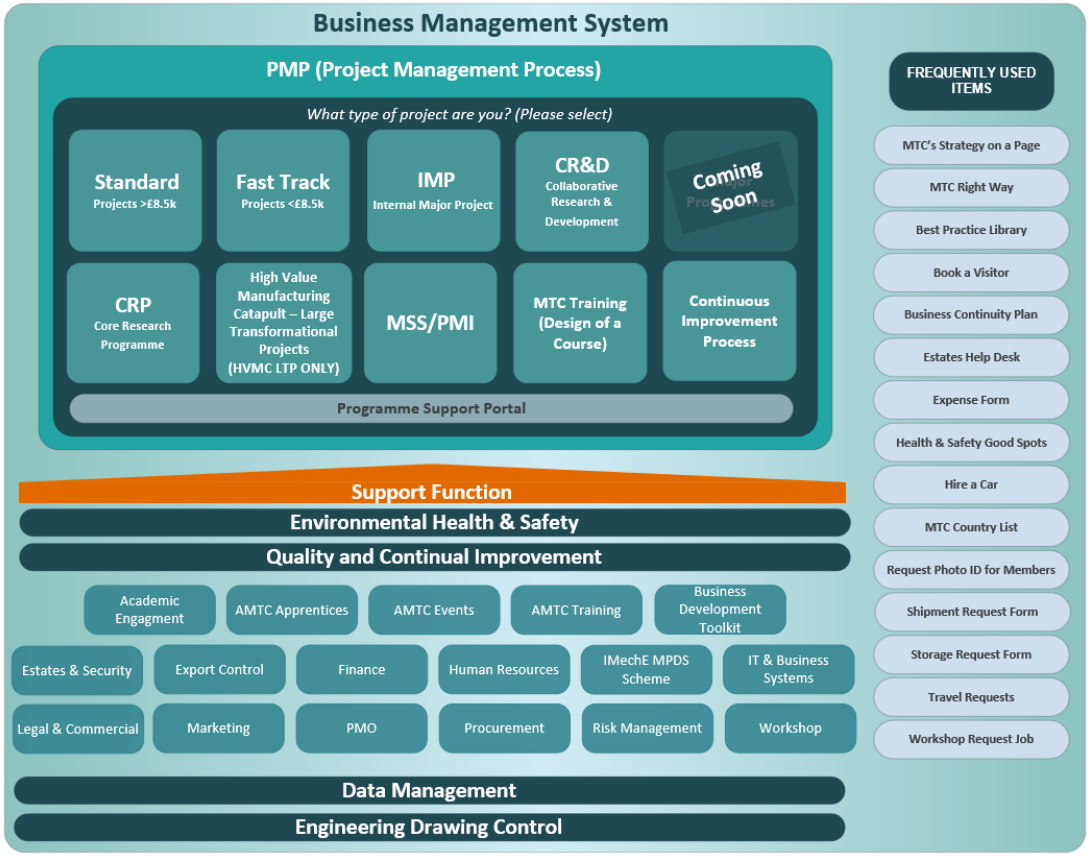
QMS: Implementation to AM @ MTC

- AM must align to the rest of your business and follow system for management of quality and business objectives
- MTC has centralised project and operations control supporting ISO 9001 and Quality Management System across our manufacturing operations including AM as part of National Centre for Additive Manufacturing (NCAM)



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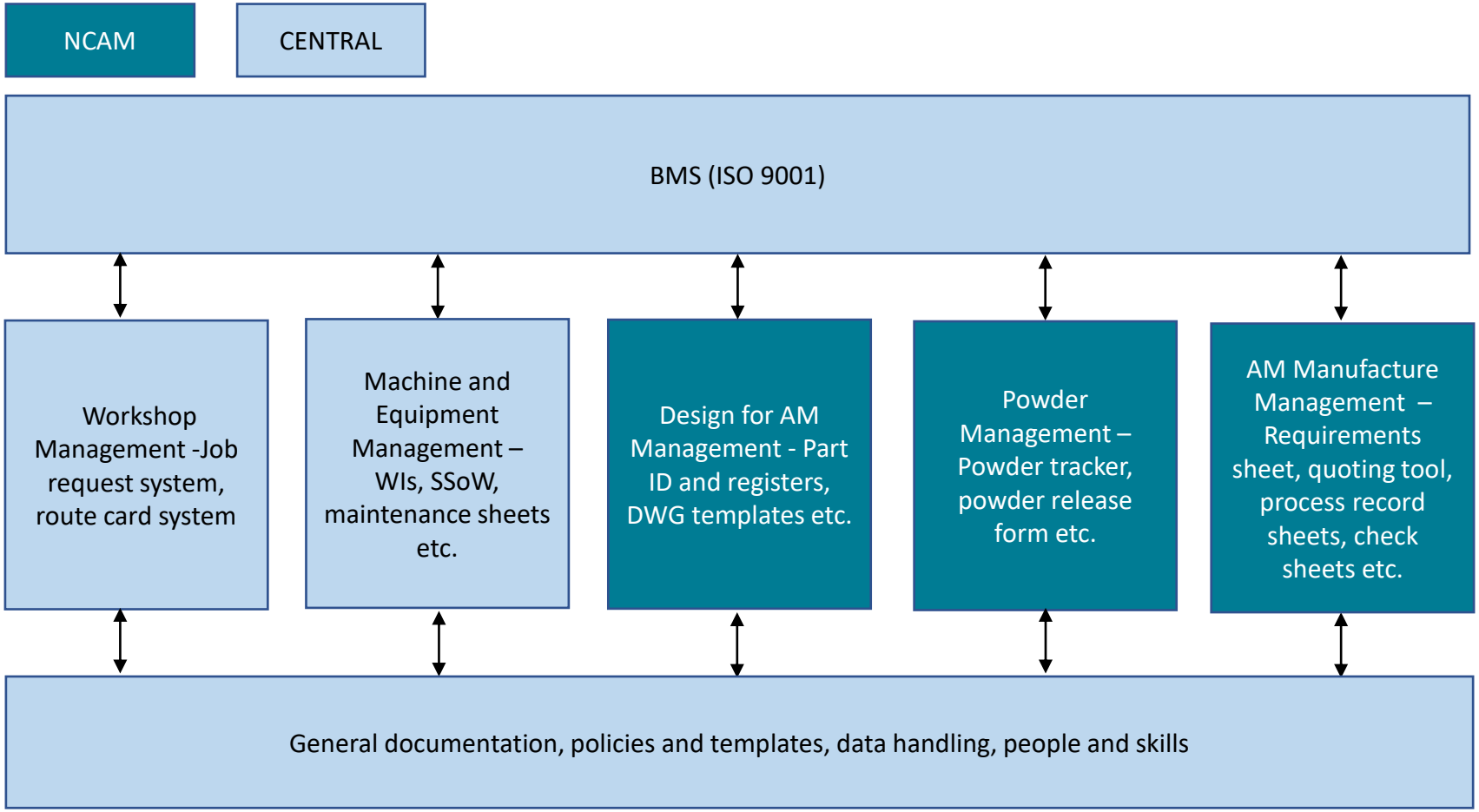
QMS: MTC Quality System Approach for AM



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EXAMPLE from MTC

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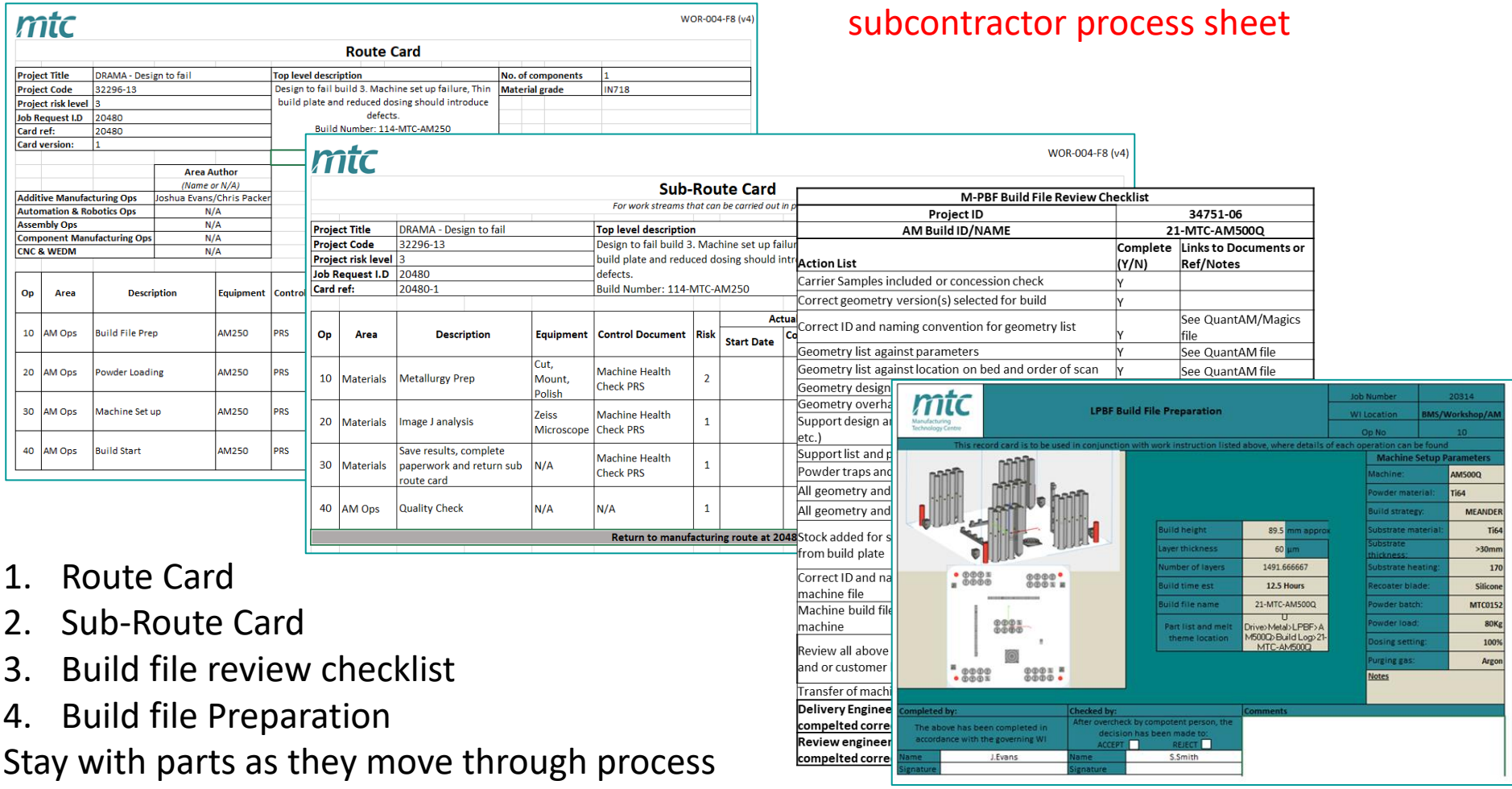
AM Production Pack

Also Job card and subcontractor process sheet



mtc — WOR-004-F8 (v4)

Route Card

Project Title	DRAMA - Design to fail	Top level description	No. of components: 1
Project Code	32296-13	Design to fail build 3. Machine set up failure, Thin build plate and reduced dosing should introduce defects. Build Number: 114-MTC-AM250	Material grade: IN718
Project risk level	3		
Job Request I.D	20480		
Card ref:	20480		
Card version:	1		

	Area Author (Name or N/A)
Additive Manufacturing Ops	Joshua Evans/Chris Packer
Automation & Robotics Ops	N/A
Assembly Ops	N/A
Component Manufacturing Ops	N/A
CNC & WEDM	N/A

Op	Area	Description	Equipment	Control
10	AM Ops	Build File Prep	AM250	PRS
20	AM Ops	Powder Loading	AM250	PRS
30	AM Ops	Machine Set up	AM250	PRS
40	AM Ops	Build Start	AM250	PRS

mtc — WOR-004-F8 (v4)

Sub-Route Card

For work streams that can be carried out in p

Project Title	DRAMA - Design to fail	Top level description	
Project Code	32296-13	Design to fail build 3. Machine set up failur	
Project risk level	3	build plate and reduced dosing should intr	
Job Request I.D	20480	defects.	
Card ref:	20480-1	Build Number: 114-MTC-AM250	

Op	Area	Description	Equipment	Control Document	Risk	Actua Start Date	Co
10	Materials	Metallurgy Prep	Cut, Mount, Polish	Machine Health Check PRS	2		
20	Materials	Image J analysis	Zeiss Microscope	Machine Health Check PRS	1		
30	Materials	Save results, complete paperwork and return sub route card	N/A	Machine Health Check PRS	1		
40	AM Ops	Quality Check	N/A	N/A	1		

Return to manufacturing route at 2048

M-PBF Build File Review Checklist

Project ID	34751-06
AM Build ID/NAME	21-MTC-AM500Q

Action List	Complete (Y/N)	Links to Documents or Ref/Notes
Carrier Samples included or concession check	Y	
Correct geometry version(s) selected for build	Y	
Correct ID and naming convention for geometry list	Y	See QuantAM/Magics file
Geometry list against parameters	Y	See QuantAM file
Geometry list against location on bed and order of scan	Y	See QuantAM file
Geometry design		
Geometry overha		
Support design a etc.)		
Support list and p		
Powder traps and		
All geometry and		
All geometry and		
Stock added for s from build plate		
Correct ID and na machine file		
Machine build file machine		
Review all above and or customer		
Transfer of machi		
Delivery Enginee compelted corre		
Review engineer compelted corre		

mtc Manufacturing Technology Centre — **LPBF Build File Preparation**

Job Number	20314
WI Location	BMS/Workshop/AM
Op No	10

This record card is to be used in conjunction with work instruction listed above, where details of each operation can be found

Build height	89.5 mm approx
Layer thickness	60 µm
Number of layers	1491.666667
Build time est	12.5 Hours
Build file name	21-MTC-AM500Q
Part list and melt theme location	U Drive>Metal>LPBF>AM500Q>Build Log>21-MTC-AM500Q

Machine Setup Parameters

Machine:	AM500Q
Powder material:	Ti64
Build strategy:	MEANDER
Substrate material:	Ti64
Substrate thickness:	>30mm
Substrate heating:	170
Recoater blade:	Silicone
Powder batch:	MTC0152
Powder load:	80Kg
Dosing setting:	100%
Purging gas:	Argon
Notes	

Completed by:	Checked by:	Comments
The above has been completed in accordance with the governing WI	After overcheck by competent person, the decision has been made to: ACCEPT ☐ REJECT ☐	
Name: J.Evans	Name: S.Smith	
Signature:	Signature:	

1. Route Card
2. Sub-Route Card
3. Build file review checklist
4. Build file Preparation

Stay with parts as they move through process

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1.Route Card

- **Manufacture operation workflow**
- **Operation workflow control gates**

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WOR-004-F8 (v4)

Route Card

Project Title	DRAMA - Design to fail	**Top level description**		**No. of components**	1
Project Code	32296-13	Design to fail build 3. Machine set up failure, Thin build plate and reduced dosing should introduce defects. Build Number: 114-MTC-AM250		**Material grade**	IN718
Project risk level	3				
Job Request I.D	20480				
Card ref:	20480				
Card version:	1				

	Area Author *(Name or N/A)*		**Area Author** *(Name or N/A)*
Additive Manufacturing Ops	Joshua Evans/Chris Packer	**Maintenance**	N/A
Automation & Robotics Ops	N/A	**Materials Labs**	N/A
Assembly Ops	N/A	**Metrology Lab**	N/A
Component Manufacturing Ops	N/A	**Customer**	Llyr Jones
CNC & WEDM	N/A		

Op	**Area**	**Description**	**Equipment**	**Control Document**	**Risk**	**Actual**		**Outcome** *(tick one)*		**Completion Stamp**	**Notes / Progress Stamps / Overcheck Stamps**
						Start Date	**Completion Date**	**C**	**H**		
10	AM Ops	Build File Prep	AM250	PRS	3						
20	AM Ops	Powder Loading	AM250	PRS	2						
30	AM Ops	Machine Set up	AM250	PRS	3						
40	AM Ops	Build Start	AM250	PRS	2						

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2.Sub-Route Card

- **Material and part flow/planning through manufacture**

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WOR-004-F8 (v4)

Sub-Route Card

For work streams that can be carried out in parallel

Project Title	DRAMA - Design to fail	**Top level description**		**No. of components**	4
Project Code	32296-13	Design to fail build 3. Machine set up failure, Thin build plate and reduced dosing should introduce defects. Build Number: 114-MTC-AM250		**Material grade**	IN718
Project risk level	3			**List component IDs**	
Job Request I.D	20480			HC1, HC2, HC3, HC4	
Card ref:	20480-1				

Op	Area	Description	Equipment	Control Document	Risk	Actual		Outcom (tick one)		Completion Stamp	Notes / Progress Stamps / Overcheck Stamps
						Start Date	Completion Date	C	H		
10	Materials	Metallurgy Prep	Cut, Mount, Polish	Machine Health Check PRS	2						
20	Materials	Image J analysis	Zeiss Microscope	Machine Health Check PRS	1						
30	Materials	Save results, complete paperwork and return sub route card	N/A	Machine Health Check PRS	1						
40	AM Ops	Quality Check	N/A	N/A	1						
Return to manufacturing route at 20480 110											

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3.Build File Review Checklist

- Key operation step information and data capture
- Operation peer review and approval

M-PBF Build File Review Checklist		
Project ID	**34751-06**	
AM Build ID/NAME	**21-MTC-AM500Q**	
Action List	**Complete (Y/N)**	**Links to Documents or Ref/Notes**
Carrier Samples included or concession check	Y	
Correct geometry version(s) selected for build	Y	
Correct ID and naming convention for geometry list	Y	See QuantAM/Magics file
Geometry list against parameters	Y	See QuantAM file
Geometry list against location on bed and order of scan	Y	See QuantAM file
Geometry design and build-ability	Y	
Geometry overhang check	Y	
Support design and connection to geometry (teeth design etc.)	N/A	
Support list and parameters	N/A	
Powder traps and powder removal possible	N/A	
All geometry and support within build envelope	Y	
All geometry and supports connected to build plate	Y	
Stock added for support or sacraficial material removal from build plate	Y	See control plan (AM CRP Project Workshop Requirement Spec)
Correct ID and naming convention for build model and machine file	Y	
Machine build file settings correct on build file and machine	Y	
Review all above against AM build requirements capture and or customer build specification	Y	Stress relief cycle defined by standard SAT/FAT
Transfer of machine build file to machine	Y	JE to complete
Delivery Engineer Signiture that all above has been compelted correctly	J Evans - 05/11/2020	
Review engineer Signiture that all above has been compelted correctly	S Smith - 05/11/2020	

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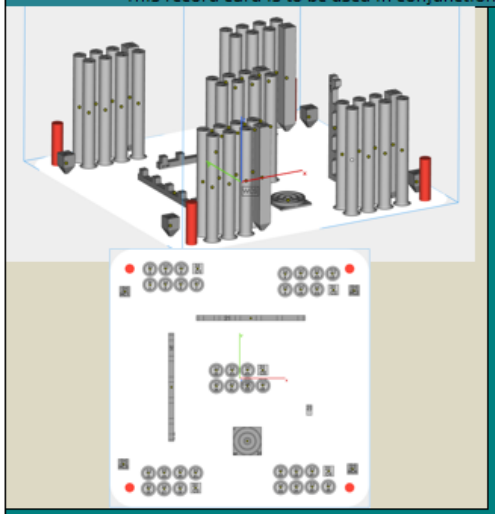
4.Build File Preparation Sheet

mtc Manufacturing Technology Centre

LPBF Build File Preparation

Job Number	20314
WI Location	BMS/Workshop/AM
Op No	10

This record card is to be used in conjunction with work instruction listed above, where details of each operation can be found



Build height	89.5 mm approx
Layer thickness	60 µm
Number of layers	1491.666667
Build time est	12.5 Hours
Build file name	21-MTC-AM500Q
Part list and melt theme location	U Drive>Metal>LPBF>AM500Q>Build Log>21-MTC-AM500Q

Machine Setup Parameters

Machine:	AM500Q
Powder material:	Ti64
Build strategy:	MEANDER
Substrate material:	Ti64
Substrate thickness:	>30mm
Substrate heating:	170
Recoater blade:	Silicone
Powder batch:	MTC0152
Powder load:	80Kg
Dosing setting:	100%
Purging gas:	Argon

Notes

Completed by:		Checked by:		Comments
The above has been completed in accordance with the governing WI		After overcheck by compotent person, the decision has been made to: ACCEPT ☐ REJECT ☐		
Name	J.Evans	Name	S.Smith	
Signature		Signature		

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Subcontract Process Sheet

If parts leave MTC for external operations (for example heat treatment);

- Production pack is retained at MTC
- Subcontract process sheet is supplied with the part showing the precise processing operations, supporting evidence required and key contact points

This mirrors what is in the PO to the company but helps to ensure that it is followed !!!

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References

- Quality Management for Organizational Excellence – Introduction to Total Quality – Groetsch and Davis
- Origin Of ISO 9000 Standards - http://www.youtube.com/watch?v=igMS5uuX4rI
- ISO 9000 Certification Dance - http://www.youtube.com/watch?v=Ipq82fL1xyQ

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www.skills4am.eu

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