

Additive Manufacturing Traceability

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Problem

Companies currently capture manufacturing information using *isolated* digital or paper based systems resulting in the lack of comprehensive **project, resource and part traceability.**

- *PLM*
- *MRP*
- *ERP*
- *Spreadsheet*
- *Post-it note*
- *Whiteboard*

What is Additive Manufacturing Traceability?

AM Traceability consists of 3 main components

- Project Traceability
- Resource Traceability
- Part Traceability

Project Traceability

Requirement Gathering

Input > Customer RFQ
Output > Project created and requirements recorded

Quoting

Input > Project Requirements
Output > Customer Quote

Order Conversion

Input > Customer Quote
Output > Work Order

3D Print Planning

Input > Work Order
Output > 3D Printing Task List

Print Analysis

Input > Print Model
Output > Print Specification

Print Model Creation

Input > CAD File
Output > Print Model

CAD Model Creation

Input > Point Cloud
Output > CAD File

3D Scan Part

Input > Physical part
Output > Point Cloud

Print Setup

Input > Print Specification
Output > Gcode

Print Job

Input > Gcode
Output > Print Set-up (Scheduled Time, Machine, Material, Build Plate, Tip) & Post Print Job Details

Post Processing Planning

Input > Printed Part & Print Specification
Output > Post Processing Task List

Testing

Input > Physical Part
Output > Testing Report

Resource Traceability

Machines



Static Information

- Manufacturer
- Model Number
- AM Process
- Build Volume
- Materials
- Serial Number
- Date of Manufacturer
- Date Delivered
- Date Installed

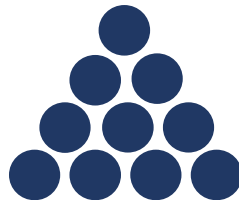
Fluid Information

- Current Configuration
- Past Configurations
- Preventative Maintenance

Job Information

- Machine Status
- Machine Utilization
- How Many Jobs

Raw Materials



Material Information

- General
- Material Usage
- Testing Information
- Active Machines
- Previous Machines
- Blend Information

Build Plates



Build Plate Information

- General
- Testing Information
- Active Machine
- Previous Machines
- Job Information

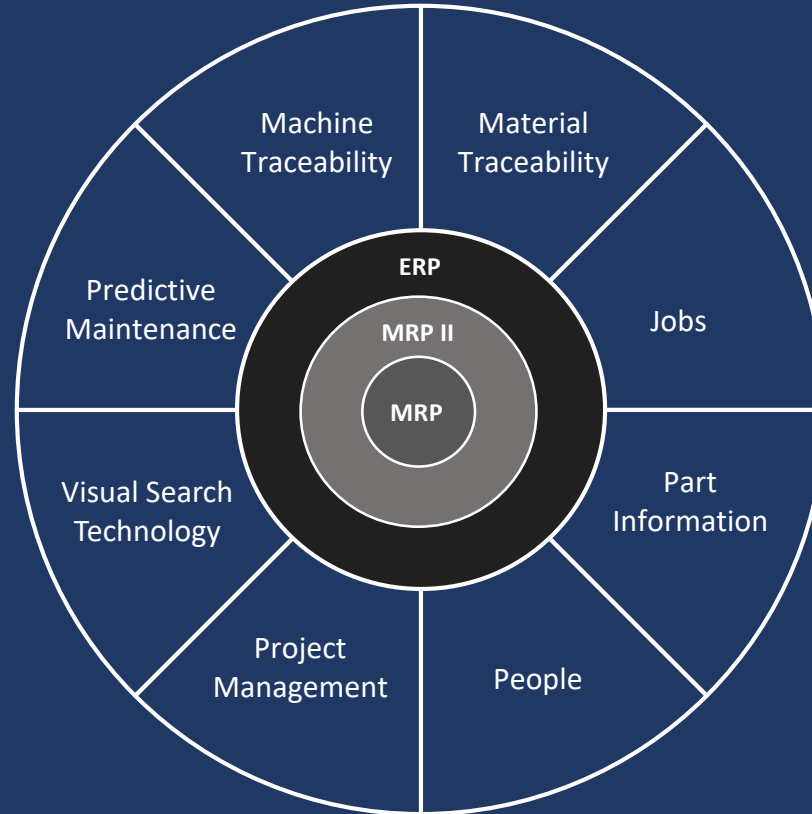
Tips



Lot Information

- General
- Material Usage
- Testing Information
- Active Machines
- Previous Machines
- Blend Information

Solution



Benefits

- Better understand the relationships between raw materials, machines, processes and part geometry.
- Print Success Predictability.
- Captured data can be used for predictive maintenance, saving valuable resources and machine downtime.
- Standardized processes.
- Traceability throughout entire project lifecycle.
- Creates project history for future reference.
- When fully leveraged, rewards can be substantial.
- One application to manage projects, people, machines, materials and jobs.

Challenges

- Integration into current systems
- Changing workflows
- Convincing companies to move to a cloud based system
- Needs to be flexible and customizable but still be user friendly

AMAS

ADDITIVE MANUFACTURING ADVISORY SYSTEM



Current Projects

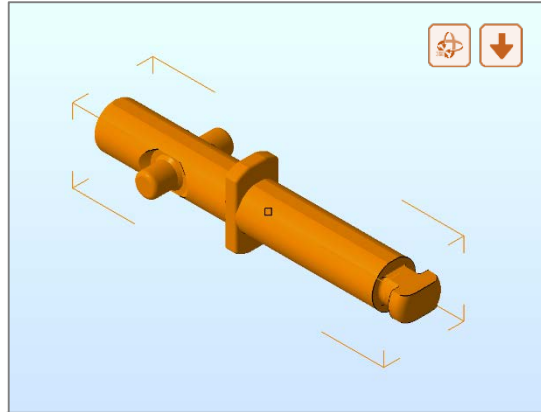
Project Name (s)	Image	Priority Level	Deadline	Required Material	Layer Height	Quantity	Machine Model
<input type="checkbox"/> <u>Actuator Arm</u>		1!	5/28/2018	Aluminum	0.01	1	EOS M280
<input checked="" type="checkbox"/> <u>Clip_pin</u>		1!	5/27/2018	ABS	0.01	4	EOS P770
<input type="checkbox"/> <u>Lock Pin</u>		3	6/1/2018	Aluminum	0.01	1	EOS M280
<input type="checkbox"/> <u>C_housing</u>		4	6/2/2018	Stainless Steel	0.01	1	EOS M400
<input type="checkbox"/> <u>Plate</u>		5	5/29/2018	Cobalt Chrome	0.01	2	EOS M100
<input checked="" type="checkbox"/> <u>Clip</u>		5	5/26/2018	ABS	0.01		

Manage tasks based on priority

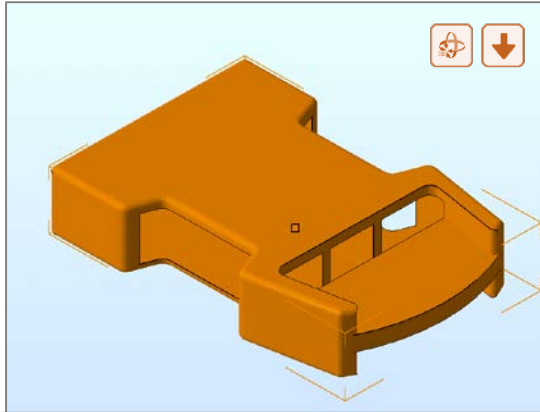
Start Working

Selected Projects

Upload important manufacturing files for downstream viewing.



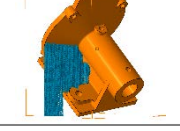
Project Name:	<u>Clip_pin</u>
Priority Level:	5
Deadline:	05/27/2018
Required Material:	ABS
Layer Height:	.01
Quantity:	4
Machine Model:	EOS P770
File Name:	Clip_pin.stl



Project Name:	<u>Clip</u>
Priority Level:	5
Deadline:	05/27/2018
Required Material:	ABS
Layer Height:	.01
Quantity:	1
Machine Model:	EOS P770
File Name:	Clip.stl

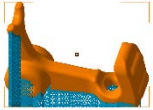
Upload Gcode plus image here
(or click here to select file)

Current Projects


Project Name	Image	Priority	Deadline	Material	Layer Height	Run(s)	Build Plate Thickness	Print Time Est.	Material Est.	Machine Type
<u>Actuator Arm</u>		1!	5/28/2018	Aluminum	0.01	1	12.7 mm	15hrs 3min	53.46 cm ³	EOS M280
<u>Clip_pin, Clip</u>		1!	5/27/2018	ABS	0.01	1				EOS P770
<u>Lock Pin</u>		3	6/1/2018	Aluminum	0.01	1				EOS M280
<u>C_housing</u>		4	6/2/2018	Stainless Steel	0.01	1				EOS M400
<u>Plate</u>		5	5/29/2018	Cobalt Chrome	0.01	2				EOS M100

Select which project to print

Job Details

Project Name	Image	Priority	Deadline	Material	Layer Height	Build Plate Thickness	Runs	Est. Print Time	Est. Material	Machine Type	Gcode
Actuator Arm		1 !	5/28/2018	Aluminum	0.01	12.7 mm	1	15hrs 3min	53.46 cm ³	EOS M280	Actuator Arm.gcode

Schedule Job

05/26/2018 8:30 am 

Select a Machine Configuration

Machine	Location	Material Lot	Current Material Level	Build Plate	Tip	Scheduled Jobs	Available
EOS M280 - West Wing	Tinker AFB - REACT	68878 <input type="checkbox"/>	2.1 lbs. <input type="checkbox"/>	BP-67890 <input type="checkbox"/>	NA <input type="checkbox"/>	2	x
EOS M280 - East Wing	Tinker AFB - REACT	234123 <input type="checkbox"/>	.25 lbs. <input type="checkbox"/>	Empty <input type="checkbox"/>	NA <input type="checkbox"/>	3	x
EOS M280 - North	Tinker AFB - REACT	546755 <input type="checkbox"/>	.1 lbs. <input type="checkbox"/>	BP-89678 <input type="checkbox"/>	NA <input type="checkbox"/>	2	x
EOS M280 - South	Tinker AFB - REACT	546755 <input type="checkbox"/>	.2 lbs. <input type="checkbox"/>	BP-324134 <input type="checkbox"/>	NA <input type="checkbox"/>	2	x

Post Print Job Details

Print Date	Actual Print Time	Actual Material Used
5/26/18 8:30 AM	7 hrs 10 min	53.46 cm ³

Select and manage machine configurations from one location.

EOS M280 – West Wing

- Static Information
- Fluid Information
- Job Information

General Information

Location	Tinker AFB - REACT	Serial Number	123456789
Machine	EOS M280 – West Wing	OC Number	12345
Manufacturer	EOS	Date of Manufacturer	05/15/2017
Model Number	EOS M280	Date Delivered	11/10/2017
AM Process	(DMLS)	Date Installed	12/03/2017
Build Volume	250mm x 250mm x 250mm	Controller Software	EOS RP Tools; EOSTATE Magic
Materials	ALSi10Mg, Nickel Alloy HX	Firmware Version	V 3.5
		Hot / Cold Spots	Click to upload file
		Build Analysis	Click to upload file

Track static machine data such as general info and maintenance.

Preventative Maintenance

Type	Scheduled Time	Actual Time	User
OEM	04/09/2018 8:00 am	Scheduled	OEM Rep
Calibrate UV	03/16/2018 8:00 am	03/16/2018 9:00 am	J. Mann
Perform Pattern Test	03/08/2018 8:30 am	03/08/2018 8:30 am	J. Mann
Clean Roller Waste	03/08/2018 8:00 am	03/08/2018 8:00 am	J. Mann
Optimize Print Heads	03/18/2018 7:30 am	03/08/2018 7:30 am	J. Mann
Check Alignment	03/04/2018 7:30 am	03/04/2018 7:30 am	T. Jefferson
Inspect Exhaust System	03/04/2018 7:15 am	03/04/2018 7:15 am	T. Jefferson
Restart Printer Computer	03/04/2018 7:00 am	03/04/2018 7:00 am	T. Jefferson
Calibrate Load Cells	03/02/2018 7:00 am	03/02/2018 7:00 am	OEM Rep

Major Maintenance 

Type	Date	File Upload	User
Replacement	3/15/2018 9:00 am	Click to upload file	T. Jefferson

EOS M280 – West Wing

Static Information

Fluid Information

Job Information

Current Configuration 

Type	Lot Number	Installed Date
Build Plate	<u>BP-67890</u>	04/05/2018 7:00 AM
Material Lot	<u>68878</u>	03/25/2018 10:45 AM
Re-coater Blade	<u>R-5253</u>	

Preventative Maintenance 

Type	Scheduled Time	Actual Time	User
Clean Wiper	04/09/2018 8:00 am	Scheduled	T. Jefferson
Clean Wiper	04/06/2018 8:00 am	04/06/2018 8:15 AM	J. Mann
Clean Wiper	04/05/2018 8:00 am	04/05/2018 8:00 AM	B. Ruth

Past Configurations 

Type	Lot Number	Installed Date	Removal Date
Build Plate	<u>BP-34123</u>	03/02/2018 10:00 AM	03/02/2018 10:00 AM
Material Lot / Blend	<u>68878</u>	03/02/2018 9:30 AM	03/03/2018 10:30 AM
Build Plate	<u>BP-324134</u>	02/24/2018 9:30 AM	02/25/2018 4:00 PM
Material Lot	<u>Unobtanium-1973</u>	02/24/2018 9:00 AM	02/28/2018 9:00 AM
Build Plate	<u>BP-234123</u>	12/22/2017 12:00 PM	12/23/2017 5:30 PM
Material Lot	<u>Stainless Steel CX-128394</u>	12/22/2017 11:30 AM	12/22/2017 11:30 AM
Re-coater Blade	<u>R-5253</u>	12/22/2017 11:00 AM	12/22/2017 11:00 AM

Track fluid machine info. For example, current and past configurations along with routine maintenance.

EOS M280 – West Wing

Static Information

Fluid Information

Job Information

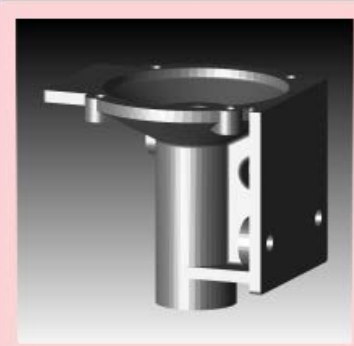
Status: Available
Utilization: 65%

Jobs (3)

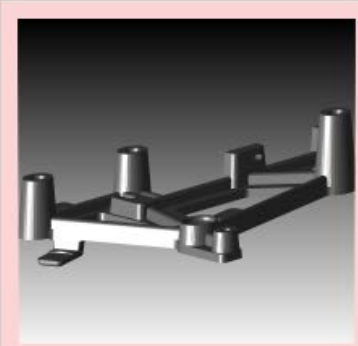
4-10-2018 **Today**
3D print Plate

4-11-2018

4-12-2018
3D print Housing



3D Print Plate
Project: Plate
User: Jason Mann
Machine: EOS M280 - West Wing
Status: **Scheduled**
Sch. start: 04/16/2018 3:00PM
Efficiency: NA



3D Print Housing
Project: Housing
User: Jason Mann
Machine: EOS M280 - West Wing
Status: **Scheduled**
Sch. start: 04/12/2018 8:30AM
Efficiency: NA



3D print Actuator Arm
Project: Actuator Arm
User: Jason Mann
Status: Completed
Sch. start: 01/06/2018 8:30AM
Efficiency: **104%**

View job information for each machine.

Virgin Material Lot - 123456

General Information 

Material Name	Unobtainium
Material Manufacturer	ACME Corp
Vendor	Wiley E Coyote
Date of Manufacture	02/02/2018
Date Delivered	03/03/2018
Date Opened	04/04/2018
Lot Number	123456
Added By	J. Mann
Added On	03/04/2018
Delivered Amount	10.0 lbs.
Remaining Amount	3.1 lbs.

Usage Information

Job/Blend	Amount Used (lbs.)	Date
<u>1234</u>	1.4	04/05/2018
<u>6734</u>	2.3	04/04/2018
<u>68878</u>	3.2	04/04/2018

Testing Information 

Carbon Content	2.4
Oxygen Content	5.6
Nitrogen Content	8.1
Sulfur Content	4.2
File Upload	TestingReport.pdf
Tested By	J. Mann
Tested On	03/04/2018
Added By	J. Mann
Added On	03/04/2018

Capture usage and testing data for virgin material lots.


Active Machines

Name	Installed Date	Current Material Level
<u>P770-1</u>	04/10/2018	1 lb.

Previous Machines

Machine	Installed Date	Removed Date
<u>WP-M100-1</u>	04/06/2018	04/08/2018
<u>EOS M280</u>	04/03/2018	04/05/2018
<u>P396-1</u>	03/20/2018	04/02/2018

Blended/Recycle Material Lot – 68878

General Information 

Material Creator	T. Jefferson
Date of Creation	02/02/2018
Lot Number	68878
Added By	J. Mann
Added On	03/04/2018
Original Amount	10.0 lbs.
Remaining Amount	2.1 lbs.

Blend Information

Material	Amount (lbs.)	Date
<u>123456</u>	5.0	04/04/2018
<u>673471</u>	3.2	04/04/2018
<u>234546</u>	1.8	04/04/2018

Usage Information

Job/Blend	Amount Used (lbs.)	Date
<u>1234</u>	2.4	04/05/2018
<u>6734</u>	2.3	04/04/2018
<u>4546</u>	3.2	04/04/2018

Testing Information 

Carbon Content	3.4
Oxygen Content	7.6
Nitrogen Content	18.1
Sulfur Content	4.2
File Upload	TestingReport.pdf
Tested By	J. Mann
Tested On	03/04/2018
Added By	J. Mann
Added On	03/04/2018

Capture usage and testing data for blended / recycled material lots.

Active Machines

Name	Installed Date
<u>P770-1</u>	04/10/2018

Previous Machines

Machine	Installed Date	Removed Date
<u>WP-M100-1</u>	04/06/2018	04/08/2018
<u>EOS M280</u>	04/03/2018	04/05/2018
<u>P396-1</u>	03/20/2018	04/02/2018

Projects

Locations

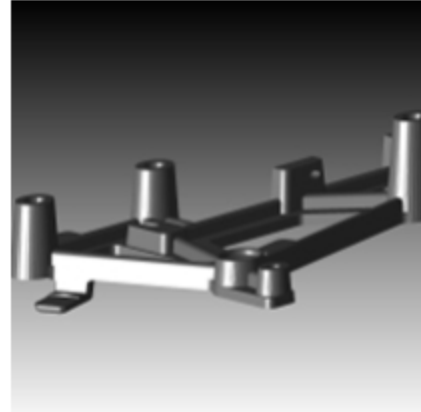
Tinker AFB – REACT (2)

View projects currently in the pipeline



Actuator Arm

Created by: Jason Mann
Location: Tinker AFB - REACT
Sch. start: 01/04/2018 8:00AM
Est. duration: 5 days
Act duration:
Status: In-progress
Efficiency: NA



Plate

Created by: Jason Mann
Location: Tinker AFB - REACT
Sch. start: 03/30/2018 8:00AM
Est. duration: 5 days
Act duration:
Status: In-progress
Efficiency: NA



Project: Plate  

Created by: **Jason Mann** Customer name: **Castco** Scheduled start time: **03/30/2018 8:00AM** Estima

View tasks assigned to each project and their current status.

Tasks (7)

3-30-2018	3-31-2018	4-1-2018	4-2-2018	4-3-2018	4-4-2018
✓ Requirements	✓ Quoting		✓ 3D Scan Part	3D Print Part	Post Processing
	✓ Create Routing Details		✓ Reverse Engineer Part		

Name	Assigned User	Scheduled Start	Est. Duration	Actual Duration	Efficiency	Files	Jobs	Comments	Status
Requirements	Clint Eastwood	03/30/2018 9:00AM	3 hr	3.5 hr	86%	1	NA	0	Completed
Quoting	Babe Ruth	03/31/2018 12:00PM	1 hr	1 hr	100%	0	NA	0	Completed
Create Routing Details	Bob Smith	03/31/2018 1:00PM	1 hr	1 hr	100%	0	NA	0	Completed
3D Scan Part	Jason Mann	04/02/2018 7:00AM	1.5 hr	1 hr	150%	1	NA	0	Completed
Reverse Engineer Part	Jason Mann	04/02/2018 8:30AM	7 hr	6.5 hr	108%	0	NA	0	Completed
3D Print Part	Jason Mann	04/03/2018 7:00AM	15 hr			2	1	0	Assigned
Post Processing	Bob Smith	04/04/2018 12:00PM	8 hr			0	0	0	Assigned

Search using this image



Refine results

Added By ▼

- Clint Eastwood (7)
- Rose Petal (9)
- Babe Ruth (3)
- Thomas Washington (12)

Customer name ▼

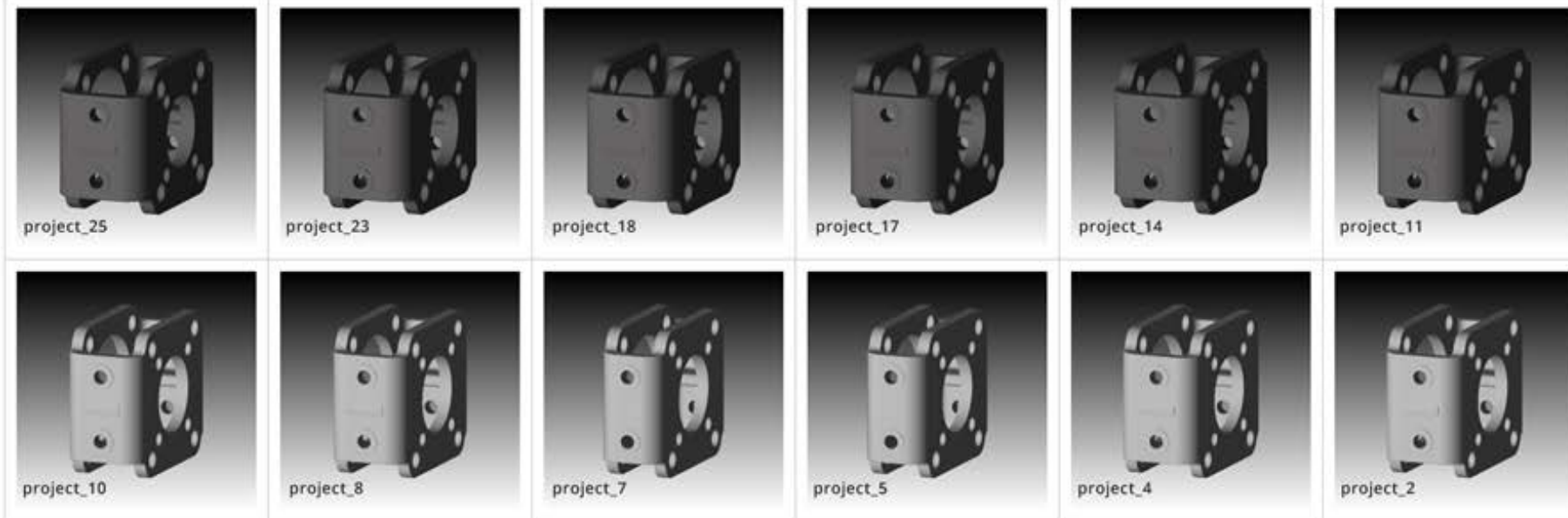
- Grippia (6)
- Corwin (4)
- Castco (2)
- Granville (14)
- Middlemass (5)

Material type ▶

Part requirements ▶

USAF

1 - 12 of 12 projects



Integrated visual search for finding similar or past projects, designs and manufacturing data.

AMAS

ADDITIVE MANUFACTURING ADVISORY SYSTEM

Questions?