2016 ADDITIVE MANUFACTURING BODY of KNOWLEDGE

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
1.0			**OVERVIEW of AM**
	1.1		Definition of AM
		1.1.1	Evolution of AM definitions
		1.1.2	Current ASTM
	1.2		Key Elements of AM
		1.2.1	Sources of Input
		1.2.2	STL File Output and Format
		1.2.3	STL File Post Processing
		1.2.4	Build Preparation
		1.2.5	Build Process
		1.2.6	Part Inspection
		1.2.7	Part Post Processing
		1.2.8	Quality Assurance
		1.2.9	Secondary Processing
	1.3		Uses of AM Parts
		1.3.1	Conceptual models
		1.3.2	Form and fit models
		1.3.3	Functional models
		1.3.4	Final product
	1.4		Industries Using AM
		1.4.1	Transportation –Vehicle – All Types
		1.4.2	Consumer Products
		1.4.3	Medical Device and Products
		1.4.4	Aerospace
		1.4.5	Defense
		1.4.6	Art and Fashion
		1.4.7	Manufacturing and Industrial
		1.4.8	Architecture
	1.5		Computer Aided Design (CAD) Tools
		1.5.1	Mainstream CAD packages w/STL export for AM systems
		1.5.2	AMF standard file format conversion
	1.6		AM Processes – ASTM Std
		1.6.1	Binder jetting
		1.6.2	Directed energy deposit

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
		1.6.3	Material extrusion
		1.6.4	Material jetting
		1.6.5	Powder bed fusion
		1.6.6	Sheet lamination
		1.6.7	Vat photo polymerization
	1.7		Current technologies that support each method/process
		1.7.1	ProJet Systems
		1.7.2	iPro Systems
		1.7.3	Eden Systems
		1.7.4	Connex Systems
		1.7.5	Desktop Systems
		1.7.6	Perfactory
		1.7.7	DraftSight
		1.7.8	ZPrinter
		1.7.9	sPro
		1.7.10	Fortus
		1.7.11	3D Touch
		1.7.12	Matrix
	1.8		Key AM Terminology – ASTM Stan dard
		1.8.1	3D printer/printing
		1.8.2	3D scanning
		1.8.3	Additive systems
		1.8.4	Direct metal laser sintering (DMLS)
		1.8.5	Directed energy deposit
		1.8.6	Fused deposition modeling (FDM)
		1.8.7	Laser sintering (LS)
		1.8.8	Rapid prototyping
		1.8.9	Rapid tooling
		1.8.10	Selective laser sintering (SLS)
		1.8.11	Stereolithography (SL)
		1.8.12	Subtractive manufacturing
		1.8.13	Surface model
	1.9		AM Materials
		1.9.1	Engineered plastics
		1.9.2	Photo polymers
		1.9.3	Metals
		1.9.4	Plaster
		1.9.5	Sand
		1.9.6	Ceramic
		1.9.7	Paper
		1.9.8	Concrete
		1.9.9	Bio-materials
		1.9.10	Wax
		1.9.11	Thermo-plastic
		1.9.12	Other materials

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
	1.10		Secondary processes
		1.10.1	Investment casting
		1.10.2	Silicone molding
		1.10.3	Urethane casting
		1.10.4	Sand casting
		1.10.5	Composites
		1.10.6	Cladding
		1.10.7	Plating
	1.11		AM advantages over traditional manufacturing
		1.11.1	Design flexibility
		1.11.2	Ease of handling complexity
		1.11.3	Speed
		1.11.4	Reduced tooling
		1.11.5	Supports mass customization
		1.11.6	Higher sustainability
		1.11.7	Ease of prototyping
		1.11.8	Mobility of production system
		1.11.9	Simplified set-up
		1.11.10	AM Integration with traditional manufacturing
		1.11.11	AM limitations
	1.12		Foundations of Quality
		1.12.1	Input quality
		1.12.2	Machine quality factors
		1.12.3	Output quality
		1.12.4	Finishing quality
2.0			**AM INPUTS**
	2.1		Input Sources and Characteristics
		2.1.1	Standard tessellation language (STL)
		2.1.2	AMF – STM F2915 file format
		2.1.3	MRI/CT scan data
		2.1.4	Point cloud data
		2.1.5	VRML
		2.1.6	3MF format
	2.2		Creation of Slice Files
		2.2.1	Concept of layered image
		2.2.2	Use of triangles
		2.2.3	Finite element analysis and output
	2.3		File manipulation
		2.3.1	File creation
		2.3.2	Verification
		2.3.3	Critical errors in STL files
		2.3.4	Repair/Modification Post Processing
		2.3.5	Software tools for modifications/corrections
		2.3.6	Reverse engineering
3.0			**AM SECONDARY PROCESSES**

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
	3.1		Definition of secondary process
	3.2		Investment Casting
		3.2.1	Investment casting patterns
		3.2.2	Wax tooling
		3.2.3	Example products – investment casting
	3.3		Sand Casting
		3.3.1	External patterns
		3.3.2	Internal cores
		3.3.3	Loose patterns
		3.3.4	Example products – sand casting
	3.4		Die Casting
		3.4.1	Direct tooling
		3.4.2	Example products – die casting
	3.5		Silicone Molding
		3.5.1	Master patterns for molds
		3.5.2	Tooling for rubber parts
		3.5.3	Example products – urethane castings
	3.6		Composite/Fiber Glass Molding
		3.6.1	Lay-up tooling
		3.6.2	Soluble cores
		3.6.3	Example products – composites
	3.7		Metal Spraying
		3.7.1	Tooling pattern
	3.8		Metal Forming/Stamping
		3.8.1	Tool Use
	3.9		Other Secondary Processes/Impact
		3.9.1	Metal spraying
		3.9.2	Metal forming/stamping
		3.9.3	Jigs and fixtures
		3.9.4	Thermoforming
		3.9.5	Paper pulp tooling
		3.9.6	EDM tools
4.0			**AM TECHNOLOGY & METHODS**
	4.1		Vat Photopolymerization
		4.1.1	Description
		4.1.2	Applications
		4.1.3	Strengths
		4.1.4	Weaknesses
	4.2		Powder Bed Fusion
		4.2.1	Description
		4.2.2	Applications
		4.2.3	Strengths
		4.2.4	Weaknesses
	4.3		Material Extrusion
		4.3.1	Description

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
		4.3.2	Applications
		4.3.3	Strengths
		4.3.4	Weaknesses
	4.4		Material Jetting
		4.4.1	Description
		4.4.2	Applications
		4.4.3	Strengths
		4.4.4	Weaknesses
	4.5		Binder Jetting
		4.5.1	Description
		4.5.2	Applications
		4.5.3	Strengths
		4.5.4	Weaknesses
	4.6		Sheet Lamination
		4.6.1	Description
		4.6.2	Applications
		4.6.3	Strengths
		4.6.4	Weaknesses
	4.7		Hybrid Systems
		4.7.1	Description
		4.7.2	Applications
		4.7.3	Strengths
		4.7.4	Weaknesses
	4.8		Directed Energy Deposition
		4.8.1	Description
		4.8.2	Applications
		4.8.3	Strengths
		4.8.4	Weaknesses
	4.9		Direct Write
		4.9.1	Description
		4.9.2	Applications
		4.9.3	Strengths
		4.9.4	Weaknesses
	4.10		Combining additive and subtractive methods
5.0			**AM DESIGN**
	5.1		Role in Direct Manufacturing
	5.2		AM Design Strengths
	5.3		AM Design Weaknesses
	5.4		AM Design Considerations
	5.5		Re-training Design Engineers
	5.6		Computational Modeling
	5.7		Design for Direct Digital Manufacturing
	5.8		Legacy Parts Optimization
	5.9		Specification of Customer Requirements
	5.10		Design Verification

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
		5.10.1	Mechanical property testing
		5.10.2	Achievable dimensions and tolerances
	5.11		Risk management
6.0			**AM BUSINESS & ECONOMICS**
	6.1		Capital Purchase
		6.1.1	Machine
		6.1.2	Facility Build/Modification
		6.1.3	Ancillary Equipment
		6.1.4	QA System
	6.2		Labor
		6.2.1	Dedicated employee potential
		6.2.2	Roles and shared responsibility
		6.2.3	Skill level(s) required
		6.2.4	Initial/On-going training
	6.3		Materials
		6.3.1	Build materials - deliverable
		6.3.2	Support cost - consumed
		6.3.3	Perishable cleaning materials
		6.3.4	Waste stream
	6.4		Maintenance Costs
		6.4.1	Maintenance/support structure
		6.4.2	Downtime risk
		6.4.3	Energy consumption
		6.4.4	Depreciation classification & implications
		6.4.5	Technology commitment costs
		6.4.6	Cost of consumables/upgrades
	6.5		Return on Investment
		6.5.1	Percent of Utilization
		6.5.2	Uptime
		6.5.3	Installation costs
		6.5.4	Employee turnover/re-training
		6.5.5	Capacity/throughput
	6.6		Outsource Economics
		6.6.1	Vendor qualification/expertise
		6.6.2	Expediting premiums
		6.6.3	Loss of schedule control
		6.6.4	Uncontrolled quality
		6.6.5	Variable pricing
		6.6.6	Cost of time to obtain quotes
		6.6.7	Risk of IP leak
		6.6.8	Diverse technology selection
		6.6.9	Flexible manufacturing/vendors
		6.6.10	Access to current technology
		6.6.11	Distributed manufacturing
	6.7		Production Cost Drivers

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
		6.7.1	Volume (cubic inch)
		6.7.2	Build height
		6.7.3	Process selection
		6.7.4	Layer thickness
		6.7.5	Scan speed
		6.7.6	Quantity
		6.7.8	Material type
		6.7.9	Post processing
	6.8		Direct Manufacturing Production
		6.8.1	Quantity sensitive
		6.8.2	High value
		6.8.3	Low part volume (cubic inch)
		6.8.4	Mass customization
		6.8.5	Design for process required
		6.8.6	Flexibility in design
		6.8.7	Support for secondary process
	6.9		Risk Management
	6.10		Legal Implications of AM
	6.11		Managing change from traditional to AM
7.0			**AM QUALITY SYSTEMS**
	7.1		Key Quality Factors
		7.1.1	Digital file configuration and control
		7.1.2	Vendor management
		7.1.3	Raw material management
		7.1.4	Device inspection/control
		7.1.5	Machine calibration
		7.1.6	Preventive maintenance
		7.1.7	Sample testing
		7.1.8	Quote and order review
		7.1.9	Production process flow
		7.1.10	Consultation for "production ready" projects
		7.1.11	Final part inspection
		7.1.12	Material and system monitoring
		7.1.13	Process file management
		7.1.14	Dimension verification
		7.1.15	Void detection
		7.1.16	Post Processing
		7.1.17	Verification of customer need fulfillment
8.0			**EMERGING TOPICS/ISSUES in AM**
	8.1		AM Design Topics
		8.1.1	Design Representation Limitation
		8.1.2	New methods for design qualification
	8.2		AM Start Ups
		8.2.1	AM industry opportunities
		8.2.2	AM investment sources

CATEGORY	TOPIC	SUB-TOPIC	DESCRIPTION
		8.2.3	AM business planning
	8.3		AM software development
		8.3.1	New software applications
		8.3.2	Software development needs in AM
	8.4		Evolution of current technologies/methods
	8.5		Integration of AM in emerging fields
		8.5.1	Robotics
		8.5.2	Internet of Things
		8.5.3	Cloud computing
		8.5.4	Remote and autonomous operations
9.0			**AM POST PROCESSING**
	9.1		Materials
	9.2		Methods
	9.3		Automating processes
	9.4		Processes for parts and components
	9.5		Processes for final products/use
10.0			**AM MATERIALS**
	10.1		Description
		10.1.1	Polymers
		10.1.2	Metals
		10.1.3	Ceramics
		10.1.4	Hybrid
	10.2		Microstructure
	10.3		Properties
	10.4		Qualification
	10.5		Vendor considerations
	10.6		Material life cycle
11.1			**AM SAFETY**
	11.1		Hazards associated with AM processing
		11.1.1	Mechanical
		11.1.2	Electrical
		11.1.3	Thermal
		11.1.4	Airborne particles
	11.2		Personal protective equipment
	11.3		Hazard communication and labeling
	11.4		Use of safety data sheets
	11.5		Maintenance and lockout/tag-out