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Trip Report / Meeting Notes

# Technology Exchange on Coordination of U.S. Standards Development for Additive Manufacturing

Penn State University

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Troika Attendee: Bob Appleton

Caveat:

The opinions expressed in this document are those of the author, based upon the views and expertise of the presenters at this conference.

## Key Takeaways:

1. Established and universally accepted standards provide risk mitigation and cost reduction by thorough documentation of the manufacturing process
   1. In the commercial sector, that benefit is greater for the manufacturer than for the user
2. The most important standards will be for machines enabling a predictable result from a given print file
3. There are 7 different Standards Development Organizations (SDO) attempting to establish standards for Additive Manufacturing
   1. This meeting was the first attempt to collaborate and harmonize that work
4. There are many existing standards that apply to Additive Manufacturing
   1. Some listed in DoD Documents
   2. Many traditional standards apply
      1. Performance standards will be the same no matter how an item is manufactured
5. Standards are not the “Silver Bullet” for A/M
   1. In situ closed loop process monitoring is far more important
   2. Testing is still required, both non-destructive and destructive
   3. “Certification & Qualification” is really a separate subject facilitated by established standards
6. Lack of standards is not preventing industry from producing “flight critical” items with FAA approval or medical devices with FDA approval
7. DoD demand for standards has more to do with the Government contracting process than it does with performance

Summary**:**

This meeting sponsored by the Penn State *Center for Innovative Materials Processing Through Direct Digital Deposition (CIMP-3D)*, and America Makes brought together 200 of the most qualified subject matter experts focusing on the need for Additive Manufacturing standards. Industry, academic and government sources were all represented. This reporter gained valuable insight into the importance of establishing standards as well as a realistic view of the limitations and challenges. It will be a very long time before a comprehensive, and agreed upon set of standards across the needs of the industry are established. According to ASTM a single new standard takes 18-24 months to write and be published.

Much valuable work is being accomplished in the absence of those standards. Industry is finding work-arounds to leverage the technology to great benefit. They have found the means to demonstrate the reliability of their A/M products to responsible government agencies. This work, mainly in the aerospace and medical fields, will accelerate rapidly. If DoD cannot find a way to participate, due to administrative or contractual restrictions, they will find themselves playing catch-up at some point in the future.

Discussion:

The following is a brief description of the main points brought out at this conference. Numbers reference the “Key Take-aways” listed above.

### 1. Risk mitigation & cost reduction

Robert Cohen of the medical device manufacturer, Stryker, made the case that establishment of A/M standards would enable substantial cost savings due to a reduced need for destructive testing to validate quality. They also foresee less legal liability in cases in which faults are found in design after years in use. So long as the item was produced in accordance with accepted standards the manufacturer could not be held liable.

### 2. Machine standards

One important area of standardization is in the machines themselves. Often sending the same print files to multiple printers will yield different results. This appears to be a case of manufacturers defending their IP to the detriment of the industry and ultimately to themselves.

### 3. Standards Development Organizations (SDO)

Seven different SDOs were named at this conference. Most were represented. Clearly there is risk of conflicting standards, duplication of effort, gaps and overlaps. When this occurs the various standards must be harmonized. This can be an expensive and time-consuming effort. Shawn Maylan from NIST related the harmonization effort between U.S and international Standards for machine tools that has been going on for twenty years. In the mean time, machine tool manufacturers must build their products to comply with two sets of standards at great expense.

The SDOs represented or named at this meeting were:

ASTM – Formerly the American Society for Test & Measurement

ISO – International Standards Organization

SAE –Society of Automotive Engineers

NIST – National Institute for Standards & Technology

ASME - American Society of Manufacturing Engineers

AWS – American Welding Society

CEN – European Committee for Standards

These are mainly US or European organizations. There may be others.

### 4. Existing standards

Several presenters pointed out that there are currently many existing standards that apply to Additive Manufacturing. Some are even documented in MIL-STDs or other government documents. MilStd 3049, for example establishes the standard for “Materials Deposition, DDM; Direct Deposition of Metal for Remanufacture, Restoration and Recoating (05-Sep-2013).”

Also, many welding standards are directly applicable to certain Additive technologies, particularly Directed Energy Deposition methods. Todd Palmer of from Penn State CIMP-3D pointed out that Electron Beam Additive Manufacturing (EBAM) is really just a multi pass welding process. He said that the American Welding Society (AWS) maintains a comprehensive library of standards including those for processes and materials, both powders and wire. NavSea Technical Publication S9074-AQ-GIB-010/248 lists the “Requirements for Welding and Brazing Procedure and Performance Qualification.”

### 5. Standards limitations

Shawn Maylan from NIST pointed out that standards alone cannot prevent defects in any manufacturing process. They are merely a “yardstick” by which to measure adherence to a defined process or performance parameter. “Certification and qualification” of items is based upon First Article testing, both destructive and non-destructive as well as validation and verification (ValVer or V&V) of sample items. When standards exist, this process is consistent providing a minimum uniform measure of acceptability.

### 6. Industry approach

In the commercial sector, A/M has been embraced. This is especially true in the medical field and in aerospace. The advantages are well known: mass customization and weight saving. In addition improved functionality and durability are often attained.

The industry approach is two pronged. In aerospace, there are many applications that are not “flight critical”. Aircraft manufacturers have identified those items and are using A/M extensively. Airbus now installs over 1,000 additively manufactured parts on each of its new airliners. These are mainly ductwork, brackets, hinges and similar parts.

Industry has also begun to additively manufacture items that are considered critical. GE has begun to retrofit a cobalt-chrome sensor housing into its G-9X engine flying on the Boeing 777. FAA approval was obtained for that last March. They also expect to receive FAA approval by the end of 2015 for the well-known fuel injector in the LEAP engine. That has successfully completed 12 months of flight testing. Stryker will have provided 1 million additively manufactured replacement knees in the US by the end of the year, according to Robert Cohen. They report a like number in the European market as well.

Each of these companies has followed a similar path. They have established internal standards and controls and proven to the FAA or the FDA that these enable them to produce reliable and repeatable products safe for the most demanding applications. In each case they are unwilling to share their acquired knowledge, considering it proprietary. It does give them a considerable competitive advantage. However, each of them would much rather have an appropriate set of accepted standards to guide their process.

### 7. DoD approach

Although the Defense Department has been exploring A/M for some time, and uses the technology for prototyping, it has some unique restrictions on the adoption of A/M for usable parts. The principal obstacle as described by Paul Huang of ONR is the requirements of Government contracting. Acquisition contracts must call out applicable MilStds to guide production of any items produced. Without such standards, the DoD’s hands are tied and they are unable to permit such contracts to be let.

Mr Huang also pointed out that Validation and Verification requires standards to measure product performance against.

## Committee Recommendations:

Breakout subcommittees were formed to develop recommendations for the way forward. A full report will be compiled and provided in the next few weeks. Recommendations included detailed lists of required standards including materials, processes, test methods and equipment. Continued collaboration, “Roadmapping” and harmonization efforts were also high on the list of recommendations. Finally it was recommended that existing standards might be examined to discover useful standards already in use. It was agreed that America Makes should coordinate these efforts.

### Last word

Kevin Slattery of Boeing noted that A/M is the first manufacturing process win which such detailed data exists. In no other process can we look into the substance of the material, examine the microstructure and possibly discover defects. We accept that a billet of titanium, for example is uniform and solid without question.