

Additive Manufacturing Consulting Practice

Leveraging AM into the Engineering Production Lifecycle

Product Lifecycle Management (PLM) is the strategic business approach that puts your products and services, and the processes by which they are defined and managed at the heart of your company—directly linked to your business strategy. PLM empowers the business, enables product and process innovation, and enhances both top and bottom-line business benefits.

Additive Manufacturing (AM) is concerned with applying additive (not subtractive) manufacturing technologies and methods to manufacturing processes. As with traditional manufacturing, AM parts have a lifecycle commencing with ideation, followed by design, optimization, simulation, validation, quality control, physical manufacturing, maintenance, and obsolescence. Processes, governance, policies, standards, and tools that support corporate Master Data Management (MDM), don't accommodate AM produced parts very well, since they were designed for traditional subtractive manufacturing. Ultimately, product data management processes, engineering and manufacturing BOMs, as well as PLM and MDM records, must accommodate both traditional and AM part information since in most cases the whole final product will comprise both traditionally made and AM made part content, i.e., a hybrid BOM.

AM is more than a standalone alternative to traditional subtractive manufacturing, i.e., AM isn't a new way to make the same part, rather it is a disruptive new engineering and manufacturing method that impacts many parts of an industrial client's business processes—from ideation through service.

Over decades, AM has been primarily used to produce models, prototypes, and one-off parts made of non-production ready materials, and without governance of enterprise solutions such as PLM, because it wasn't deemed necessary. Now, with recent advances in material science, new high performance AM machines, improved CAD and simulation tools, together with commercial pressures to make things faster, lighter, stronger, and cheaper, and to have parts available when and where needed, an exciting new mainstream era for AM is emerging. To fully adopt AM, however, it needs to be assimilated into mainstream organizational processes and business solutions such as PDM, CAD, and ERP.

CIMdata's AM consulting practice adds knowledge, know-how, roadmaps, best practices, and knowledge about available solutions and their providers to CIMdata's well-established PLM-focused consulting services. AM is a critical new

technology, but it requires different design and lifecycle considerations to maximize its value.

The New Wave of AM

New product development has changed significantly over the past 30 years. New products may now be 80% the same as an existing or old product, may comprise up to 100% of Original Design Manufacturer (ODM) content from external suppliers, and have final design definition done by procurement rather than engineering. PLM solutions did not fully contemplate this complexity of management challenge. Similarly, product engineers never contemplated making parts that didn't need tooling; they typically designed from geometric features themselves then subsequently validated their choices using various types of analyses and other simulation tools, and fashioned product assemblies based on the paradigm that discrete parts would be individually produced and assembled with fixing devices (e.g., bolts, screws, or adhesives). The 5000-year-old approach to design suddenly needs reevaluation and reinvention!

AM impacts how we conceive products, design them, optimize them, manufacture them, manage change, maintenance, and logistics.

Impact of Additive Manufacturing

Design

Man has been designing and making things the same way for thousands of years. From the ancient Sakkara tombs and pyramids to the Freedom Tower in NYC, even an iPhone; man envisions, designs, makes parts, assembles them in a defined sequence, and eventually creates the hoped-for product that conforms to desired usage, aesthetic, and quality principles; all within budget and on time. AM offers a new approach entirely. To truly leverage AM in production, engineers must unlearn thousands of years of design and manufacturing conventions, and embrace new and evolving Design for Additive Manufacturing (DFAM) practices.

Data & Process Management

AM part production follows a specific workflow within the AM workgroup, but to fully adopt AM into production, AM needs to be assimilated into an organization's enterprise processes and business solutions, such as PDM, CAD, ERP, and Supply Chain (SC), to ensure corporate governance. Yet

there needs to be a balance between supporting productivity of the workgroup (including individual desktop users), and the demands of the enterprise systems to maintain governance. The AM workgroup needs intra-workgroup specific workflows closely coupled with the DFAM tools and physical machines, while also ensuring all released work is checked into and mastered in PDM. Easy bi-directional integrations must facilitate ECO processes, material selection, supplier selection, etc. Too much governance by PLM compromises the efficiency of the workgroup and individuals, too little and enterprise governance is compromised. The ideal balance supports free collaboration and design changes within the workgroup, but robust management providing auditability and traceability at enterprise level.

Manufacture

Assuming the AM part is intended for production purposes, its “function” guides the printing technology and material selection to be used. Examples of printing technology include Direct Metal Laser Sintering (DMLS), Selective Laser Sintering (SLS), and Stereolithography (STL). This choice in turn defines the target AM machine type and printing and post-processing parameters. For example, if SLS is chosen then structures to support the part during printing are not needed. If, however, STL is chosen then the DFAM file must contain support structures to stabilize the object during printing and cooling. Besides the single *part* characteristics, e.g., weight, size, strength, and geometric complexity, other characteristics such as unusual lifecycle business characteristics should also be considered. These business characteristics may include manual touch during manufacturing processes, re-work loops, set up time, and jigs and fixtures to support multi-step traditional manufacturing processes. These are real “business costs” which can justify or defray the cost of investing in AM.

Maintenance

Maintenance cost can be another unusual lifecycle business characteristic to justify AM since “print replacement” rather than “repair existing” (part), may be faster and/or cheaper with lower human intervention required. AM can reduce inventory of finished parts by providing on-demand production-ready parts at or close to the location of service, thereby reducing cost of inventory and shipping. Additionally, the high cost of maintenance of old products for which design records, either digital or paper, do not exist, may provide a business justification for AM. In this case, a scanner can be used to capture the physical artifact, then software can be used to edit or improve the geometric definition before sending it into CAD or direct to the AM machine.

The CIMdata Approach

CIMdata’s six stage *PLM Transformation* strategic consulting methodology recognizes that the successful planning, selection, and implementation of new business strategies and

solutions involves ongoing, and iterative processes. This applies to every organization—whatever the industry, whatever the requirements or applications, and whatever the desired result. Each of the six phases (as illustrated below) is separate and unique. Each is equally important, and for the outcome to be successful, each requires a set of targeted activities. CIMdata is ready and experienced to provide support during each phase.

The AM Consulting Services concentrate on strategy definition and how to best leverage new AM design methods, technologies, and workflows. Many companies are already using AM, but often as a separate point solution—as a tool outside the mainstream engineering workflow. Yet a huge potential remains in leveraging AM in the mainstream engineering processes, which means understanding how AM fits within the overriding enterprise workflows managed by various product lifecycle management solutions, e.g., CAX, PDM, ERP, and SC.

CIMdata’s Consulting Framework



CIMdata provides client-specific support across its phased consulting methodology—totally tailored to our client’s AM implementation planning needs. Each support phase is described in the following sections.

Strategy Development

An AM business strategy with clear metrics and objectives is essential before adopting AM into production. There are both upstream and downstream consequences to consider. What can we “not” do by using AM and what are the savings? What will AM enable us to do that we can’t do today? It could be new products, in new markets, or disrupting traditional markets including the value chain. Whatever the AM strategy is, it should be clear, and articulated within a business

strategy. CIMdata has 30+ years helping clients develop strategic plans for PLM, so understand how to adopt AM into enterprise workflows.

Solution Definition

CIMdata's consulting methodology includes several tailored activities that support the development of a detailed solution definition. For example, an AM maturity assessment is used to understand the existing barriers to AM adoption and the gaps relative to conventional design, analysis, simulation, and manufacturing planning.

As the leader in AM strategy development, CIMdata brings the most comprehensive view of tools, processes, and techniques that can be applied to meet specific business objectives. CIMdata also assists our clients in aligning functional organizations such as R&D, engineering, manufacturing, operations, and information technology to create an optimum solution that satisfies the business needs of each organization individually and collectively.

Solution Evaluation & Selection

CIMdata's extensive understanding of the commercially available AM solutions dramatically reduce the time needed to evaluate and select the most appropriate AM solutions that are aligned with an organization's business and process requirements. CIMdata's evaluation and selection methodology helps an organization focus on the business and technical issues that are most critical to achieve its strategy and vision. Leveraging CIMdata's knowledge of the available solutions and our clients' specific requirements, we can provide a shortlist of appropriate AM design, simulation, and/or printing solutions for further evaluation.

Implementation Planning

Upon the selection of the appropriate AM-enabling solutions, CIMdata's support continues throughout the implementation planning phase of our client's project. Over the years, CIMdata has provided a significant amount of strategic advice and counsel during this critical, but often overlooked phase of a project. CIMdata offers the same best practice support for AM including statement of work development, contract negotiation, implementation team structuring, "to-be" process definition, systems definition, cultural and organizational change management, training planning, education, and others.

Implementation Support

As with any other new strategic solution implementation, AM deployment requires active implementation support and leadership engagement. With the proper support provided by CIMdata, improvement progresses quickly. CIMdata assists with creating a team of change agents, representing different lines of business (e.g., R&D, engineering, manufacturing, operations, logistics, procurement, maintenance, and IT) that

must be assembled to push adoption deep into the organization.

AM implementation success requires executive sponsorship. CIMdata provides guidance to executive leaders to direct and influence the organization. The executive sponsor must be actively engaged and enthusiastically willing to promote collaboration. Influence, respect, and likeability are key success factors. CIMdata assists leadership with developing clear, simple, and straightforward AM guidelines. The emphasis is on innovative new AM workflows to reduce cost in numerous ways (e.g., material reduction, product complexity reduction, tooling reduction, simplified workflow, reduction of inventory and capital equipment, and faster time to production).

Additionally, CIMdata assists with defining and establishing networks (i.e., communities of AM practitioners) and leveraging them effectively towards common goals. CIMdata also supports "lunch and learn" workshops to share ideas and best practices, and to foster collaboration and participation.

Monitoring & Continuous Improvement

The primary means of measuring AM success, besides business metrics, is to identify and celebrate successes as well as "smart" failures that lead to organizational learning. It is also important to recognize the power of collaborators and innovators, and how they are positively impacting business objectives. Recognizing the "most innovative" person, and how they succeeded adopting AM on their project is one step in motivating the organization to use the new AM tools to design and manufacture innovative products. However, CIMdata's research and experience indicate that such extrinsic metrics cannot sustain ongoing adoption and are not scalable to volume production. What's needed for AM to be successful in the long-run is a clear business plan that everyone understands, and more importantly, supports. CIMdata helps drive AM business planning.

Additionally, CIMdata leverages a set of assessment techniques and other best practice experiences to identify areas requiring improvement and then recommends roadmaps to move forward.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions. Since its founding over thirty years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM-enabling technologies.

CIMdata works with both industrial organizations and solution providers of technologies and services seeking competitive advantage in the global economy. CIMdata helps industrial

organizations establish effective PLM/AM strategies, assists in the identification of requirements and selection of PLM/AM technologies, helps organizations optimize their operational structure and processes to implement solutions, and assists in the deployment of these solutions.

For PLM/AM solution providers, CIMdata helps define business and market strategies, delivers worldwide market information and analyses, provides education and support for internal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

In addition to consulting, CIMdata conducts research, provides PLM/AM-focused subscription services, and produces several commercial publications. The company also provides industry education through PLM certificate programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia-Pacific.

To learn more about CIMdata's services, visit our website at www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0) 495.533.666.