Chapter 13
Purchasing Process Consequences After In-house Additive Manufacturing Adoption

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Abstract Additive manufacturing (AM) is nowadays a major and very relevant manufacturing key tool in many manufacturing companies that seek to improve business competitiveness by adjusting processes to highly demanding customer requirements. This particular study seeks to deepen the understanding of additive manufacturing adoption impact into aerospace companies purchasing process. In the study, it had been analyzed the potential consequences that would be expected on the aerospace companies purchasing processes, after the adoption of AM considering the scenario in which AM is implemented in-house the aerospace companies. Expected process changes identified in the study are both an important organizational opportunity and also a serious threat for quick AM adoption at aerospace companies.

Keywords Additive manufacturing · Aerospace industry · Purchasing process · 3D printing

13.1 Introduction

One of the most significant drivers in manufacturing new edge is the emergence of new manufacturing technologies that could enable companies to manage cost efficiency and small-scale production, such as personalization [21, 36, 37] and additive manufacturing [18, 46]. Additive manufacturing (AM) started few years

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ago to become a manufacturing methodology that it was successfully applied in different industries and companies, and quickly, it got a relevant displacement of other traditional manufacturing methodologies [3].

However, for many companies, AM is not more than a different way of manufacturing goods in small scale, rather than a revolutionary way to handle specific manufacturing operations which can get some additional advantage from this technology benefits, to improve competitiveness and customer service level [11].

Early seventies, Ciraud launches the first initial technology that could be considered as an indicator of the current AM technology [6]. Few years later, Kodama and Herbert launched the first devices that worked with a technology called "3D printing", and it was known later in a more comprehensive way like "additive manufacturing" [34]. In 1986, Hull developed the "stereo-lithography machine" [23], and that equipment could be considered as the first one really capable to manufacture pieces in three dimensions.

Additive manufacturing most relevant current application is "rapid prototyping", usually considered as the more extended application. To manage prototyping manufacturing, process includes a 3D model-based design to run with a computer-aided design software and combined with a manufacturing 3D printing technology unit [39]. Prototypes are ease to operate and feasible to make in many trials at an affordable cost. Since one piece manufacturing is not a hard issue, "small batches production" is applicable at situations in which an isolated unit or a rather limited number of units should be manufactured.

When 3D manufacturing is applied, production could be efficient even in case of production decentralization. This means that with AM [22, 42] would be possible a simplest and shorter supply chain, so a number of geographically distributed printers could meet local demands reducing significantly transport costs and order—to—delivery lead times. Industries like the fashion sector [8, 17] guest that AM could be applicable in a near future by certain companies as a breakthrough alternative to improve their customer service via lead times reduction.

Although it is possible to identify some disadvantages versus traditional subtracting manufacturing processes, as the limited volume of products to be executed since AM is not prepared till now to make many units of the same piece, also, AM is limited to certain raw materials and colors [38].

Adoption of AM appears to herald a future in which supply chains could be shorter, smaller, more localized, more collaborative and offer certain sustainability advantages over traditional manufacturing process [20]. In the frame of AM future applications, it is possible that additive manufacturing application could be extended to numerous industries [26]. Nowadays, main applications are: (i) consumer electronics products, including fashion, toys and jewelry, (ii) automotive industry, mainly for prototyping, (iii) medical and dental solutions, more than half of the hearing aids and orthotics are currently produced using 3D printing and (iv) aerospace industry, which could reduce the buy-to-fly ratio due to the possibility of replacing heavy components by elements made of titanium and nickel [24, 35].

In addition to these examples, other applications are being developed in areas as food-related applications [16, 28, 43] and some new research on healthcare applications as the study which is searching on biological structures that could be created in digital form somewhere and delivered worldwide to be finished and personalized anywhere the right equipment for additive manufacturing would be available [40, 41].

Also, it could be identified some sustainability benefits [18] as: (i) extended product life: based on technical approaches such as repair, remanufacture and refurbishment, (ii) improved resource efficiency: Improvements can be done easily at any moment of product cycle life and (iii) reconfigured supply chains: Shorter and simpler supply chains are feasible via new AM and distribution models.

Regarding aerospace industry, the use of AM technology is increasingly widespread in the aerospace industry [32, 35]. Aerospace industry has been one of the pioneer sectors on AM adoption. There are several examples as Boeing that introduced by the end of 2015 about 20,000 original parts based on AM technology [13, 30]. Airbus [1] produces several metal parts made on titanium using AM for its most modern aircraft as A350 XWB. It is an objective of this study to go deep into the consequences of AM adoption on aerospace industry with the particular aim of getting a higher knowledge of particular impact on purchasing organization process.

13.2 Objective and Study Methodology

This study is trying to deep into the understanding of to what extent additive manufacturing development and application is affecting to the aerospace industry supply chain, in particular in the purchasing processes. Study could be particularly important for the aerospace industry since a major part of their components is outsourced to third parties. Global research plan has different phases and includes several different scenarios, combining scenarios quite different from in-house manufacturing in which focal company manages all production processes to those in which outsourced manufacturing is performed by third-party suppliers.

In this case, the research is focused on the consequences for the aerospace manufacturer purchasing process when company decides to implement AM within its own in-house manufacturing versus a previous situation in which the components were fully manufacture by a third-party supplier. The analysis will be focused on the issues and potential benefits for the aerospace company after taken this in-sourcing AM decision.

Authors try to identify potential threads and benefits for the aerospace manufacturer when decided to make in-house components previously outsourced to third parties, trying to get benefit of AM technology implementation. Academic studies have tried to identify some benefits of AM in supply chain management [5, 19, 29, 49]. Some studies identified certain benefits of AM technology within the aerospace supply chain industry as: (i) inventory reduction, (ii) higher reaction speed and (iii) lead times significant reduction [27, 33]. AM technology applications increasingly widespread in the aerospace industry [32].

This study tried to go further and aims to understand the current and future applications of AM technology as a factor that could strongly transform the aerospace industry supply chain by influencing its purchasing process. Authors based the research analysis on a deep and detailed review of relevant available published data regarding aerospace sector companies practice and authors professional own field experience in AM projects and purchasing process reengineering during many years.

13.3 Additive Manufacturing Influence in Aerospace Supply Chain

To analyze the supply chain [44], it would be necessary to consider those processes identified by the supply chain operations reference model or SCOR model [7]. Main supply chain processes were defined as: make, source, delivery and return [15, 31, 45]. Following figure (Fig. 13.1) shows a simplification of the typical global process in the aerospace supply chain. Figure 13.1 shows the most relevant stages, from the design to the recycling at the end of its useful life.

An aircraft is built in its final assembly line based on major structural building blocks delivered by Tier 1 suppliers. Those building blocks include hundreds of parts supplied by Tier 2 suppliers. Supply chain management and purchasing process have become key success factors for the aerospace industry [12]. As example of its relevance, an A380 aircraft incorporates more than 2.5 million different parts, and 70% are sourced from 1500 suppliers [49].

The main functions involved in an aerospace purchasing process are described at the following Table 13.1.

These six functional levels are not the only ones in the whole purchasing process, but they are the most relevant ones. Those functions could be found on every purchasing process of any aerospace company. In this paper, the analysis is focused on first four levels (A to D). Levels E and F are transversal support function to A to D and having much lower exposure to any manufacturing technology change.

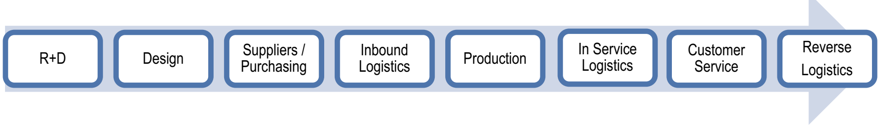

Fig. 13.1 Aerospace industry supply chain. *Source* authors own elaboration

Table 13.1 Main purchasing functions and responsibilities

LEVEL A—Strategic Purchasing. Responsible of leading the commercial negotiations, defining the purchasing strategy and maintaining the B2B high-level relationships
LEVEL B—Operational Purchasing. Accountable for supplier performance, deliveries follow-up, order release, inventory decisions and recovery plans when necessary
LEVEL C—Logistics Control. Responsible of logistics and warehousing, forwarding follow-up, warehouses management the incoming inspection
LEVEL D—Purchasing Quality. In charge of supplier quality performance, supplier's process control, audits and industrial capacity assessments
LEVEL E—Purchasing Coordination. Focus on the coordination between all purchasing functions. Level E implements processes and manages the prioritization of tasks
LEVEL F—Supplier Development. This function is transversal to the other purchasing functions and dedicated to develop strategic suppliers

Source authors elaboration

13.4 Discussion When AM is Applied In-House Aerospace Plant

If the aerospace manufacturer decides to produce a specific aircraft component in-house, they need specialized suppliers [2, 9, 10], which are companies with very specific technical capabilities. After the adoption of the AM by the aerospace manufacturer [4, 14], supplier manufacturing relation ends. Function of collecting base material and productive machinery will continue, but now managed within the aircraft manufacturer organization. Manufacturer´s purchasing process will take over all the tasks previously performed by the supplier, and this means a quite relevant organization change [25, 47, 48] to adapt from traditional final components purchasing to the purchasing of 3D printers and raw materials sourcing. The impact on each purchasing function of the aerospace manufacturer is analyzed in Table 13.2.

Level A purchasing function, before AM adoption by the manufacturer, it was responsible for tender launching to suppliers, negotiations and to improve constantly the value for money. After change over to AM, its job will be focused on negotiating 3D printers purchasing conditions, and the process not only undergoes a change in technical expertise, but also could cause a drastic reduction of its daily workload.

Level B controls the work in process and manages the inventory. After switching to AM, new vendors would no longer be as specialized as previous suppliers before AM. New vendors will be powdered metal or consumable yarn suppliers, depending on the type of printer. The number of references purchased would be significantly reduced, and inventory management would be simplified.

Level C, who deals with logistics control, reception, warranty confirmation and storage until the moment of internal consumption, would now manage fewer references, mainly consumable raw materials for printers. And finally, the Level D that is involved in a traditional manufacturing process as quality assurance control function when purchasing parts responsibility, it will move its tasks after the adoption of the

Table 13.2 Impact on aerospace company purchasing functions

Level A	Before AM	After AM	Level A_AM impact
- Negotiations strategy - Contracts man	- OEM continuous improvement	- 3D printers purchasing	- Tasks reduction - Cost reduction
Level B	Before AM	After AM	Level B_AM impact
- Procurement - Follow-up - Inventory man	- WIP control - Inventory and technology management	- Purchasing comp - Inventory management	- Lower WIP and less industrial expertise required
Level C	Before AM	After AM	Level C_AM impact
- Logistics - Inspections	- Logistic control - Warehousing	- Less logistics/space management	- Cost savings - Easer logistics management
Level D	Before AM	After AM	Level C_AM impact
- Process control (audits)	- OEM process control - Audits suppliers	- AM raw materials process control	- Cost control reduction - Standardization

Source authors own elaboration

in-house AM and will take responsibility only for the quality of the purchased raw materials. The process could be ever simplified by the reduction of references to be managed.

13.5 Conclusions

After the study that was performed, with the aim of going deep into the aerospace supply chain and particularly focused on its purchasing processes, it could be inferred that when aerospace manufacturers would implement in-house AM (from precious outsourced traditional manufacturing), the purchasing processes will be drastically modified and simplified. One of the clearest effects can be recognized as a quite shorter supply chain after in-house AM implementation, and this will lead to a relevant lead times reduction.

After analyzing the different functions included in the aerospace purchasing process of a typical company, several relevant changes are identified as it was described at previous analysis. Previous changes, by purchasing function, will mean some corresponding benefits such as lower inventories (consequence both from simpler inventory management and lower replenishment lead times due to the new technology). Another direct effect could be less space occupied at company warehouses.

Additional consequence that will be very relevant in term of cost involved will be linked to the amount of people needed to manage the “new purchasing role”, a lower amount of human resources would be required. Initial estimations show that this would have a major impact in term both of cost reduction and new skills required on the future when aerospace company will be under an in-house AM environment. On top of that, an increase on the relevant suppliers' specialization (AM process design) based on their know-how, and a tendency to decouple between design and production activities, in such a competitive industry could also be foreseen.

According to the potential benefits, AM will probably be adopted in the aerospace industry gradually since the effect in term of people roll and skills is quite significant. It could be expected that initially main application will be focused on low mover parts, but in the long run, it will likely be most probably that this manufacturing technique even would be feasible and profitable in the mass production parts.

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