Why is SAM project interesting for industry?

1. Current situation

Having skills in Additive Manufacturing (AM) today means job security. This makes life easy for people not knowing what to study or obviously for people having these skills. It is however bad news for the make-industry: there is a serious shortage of skilled people, even to the extent that it is slowing down the growth of the AM-industry. Companies are struggling to find skilled personnel. This is the main motivation behind the SAM-ERASMUS+ Blueprint project Sector Skills Strategy for AM (SAM) and its goal is to fill this need by reshaping the AM-related education.

A naive approach would be simply setting up more AM-training centres (at universities, branch organisations, in-house industrial trainings…). This would be, apart from being very costly, be insufficient. To understand this, it is important to analyse carefully all reasons behind this shortage. It is not only the fact that there are not enough training centres available.

1.1. Young technology

AM is a relatively young technology. In its' modern form, early examples of (industrial) Rapid Prototyping (RP), as it was called back then, appear in the mid-1980s, while the first (synthetic) plastic in injection moulding was patented back in 1909. Casting even goes back to the Bronze Age (3300 BC). Obviously, these more traditional manufacturing technologies have had more time to develop and are part of the standard educational packages in schools and universities dealing with manufacturing.

This is not the case for AM, there are not so many dedicated courses. In many schools and universities, they are part of courses with names like *Non-conventional manufacturing processes*. Sometimes, however, it is not part of the curriculum at all. Needless to say that this does not contribute to the growth of the AM-working force.

1.2. High growth

Since the 1990s, the industry has been monitored closely by Wohlers Associates[1]. Figure 1 gives an overview of the total market evolution until 2018. Today, the AM-market is worth 10 billion $ annually. The right graph shows the evolution of the growth rates. The last 10 years where (almost) consistently over 20%. Even before that, the growth rates were much higher than the average global industrial growth over all sectors. A staggering 33.5% growth in 2018. This causes an extreme raise in demand for skilled people to realise this growth.

[1] https://wohlersassociates.com/

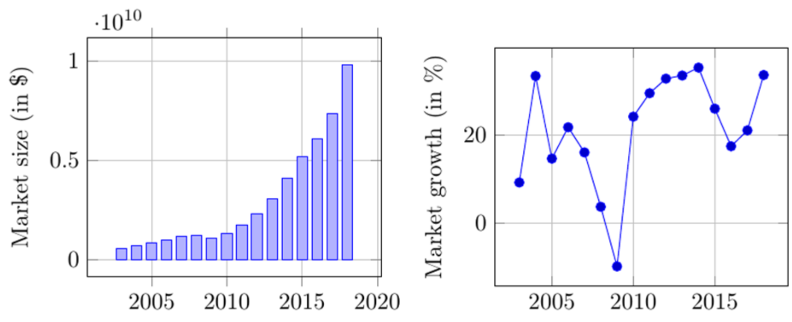

Figure 1: AM-market evolution until 2018 (Source: Wohlers report)

1.3. Fast evolving

This growth cannot be caused only by the natural growth of existing markets, then it would be closer to the overall industrial growth of only a few percent. In order to reach these extreme growth rates, new applications and markets need to be addressed, consistently. This in its turn is only possible due to continuous improvement of the AM processes and materials being used, as well as application specific research. As a consequence, the industrial evolution in AM goes hand in hand with the scientific and technological advances being made and does so at a very fast pace.

The result is a continuously changing state-of-the-art. A person having followed a course five years ago is no longer up-to-date. Also, the courses themselves, given five years ago, are no longer up-to-date. Both need to be updated continuously.

1.4. Large diversity of AM-technologies

These fast evolutions do not only need to improvements of existing AM-technologies but have also generated a wide variety of different AM processes. This is reflected in the standard ISO/ASTM 52900. In order to have some structure in the wide variety of processes, a (standardised) classification of all these processes is defined. There are basically seven types of processes:

- binder jetting
- directed energy deposition
- material extrusion
- material jetting
- powder bed fusion
- sheet lamination
- vat photopolymerization

Each type of AM-process has quite a number of variants. It is very difficult to stay up-to-date with this large number of technologies. Fortunately, most of the time, it is also unnecessary to do so for the basic user. A training centre should at least be aware of the state-of-the-art but can specialise in a subset.

1.5. Impact on the complete product life cycle

Perhaps the most difficult problem to handle is the fact that if a person is trained in AM and becomes skilled in all aspects of the material and process, the training focuses on the manufacturing itself. AM is treated as yet another manufacturing technology. In many applications, the existing manufacturing process for a part is simply replaced by an AM process. The engineer typically looks only at the manufacturing process to produce an existing part. Why does he or she do that? Because it is faster and/or cheaper (no need to make a mould).

This is not exploiting AM to its' fullest extent. AM opens up completely different approaches to product, design, manufacturing, logistics, in fact, the complete product life cycle. In a way, it relates to one of the famous quotes by Henry Ford:

> *If I would have asked my customers what they wanted, they would have answered: A faster horse.*

The car actually started a completely new approach to transportation. The new approach to designing, making, selling, delivering and recycling a product is not treated sufficiently in modern education.

2. The role of SAM-ERASMUS+

2.1 Requirements on education

The set-up of the SAM-ERASMUS+ project and the targeted goals are defined according to the (industrial) needs described above. These needs translate into some quite challenging requirements for AM-educational programmes:

- Stay up-to-date: This isn't obvious because of the fast evolving technology
- Offer modular courses. Because of the wide variety of AM-technologies, it is not possible to have all skills train to all people. It is not required either. Therefore, it should be possible to have AM-courses *à la carte*.
- Go beyond the *mere* manufacturing. In order to fully exploit the possibilities of AM, all aspects of the process and materials need to be adapted accordingly. This is not obvious. Therefore, other aspects (design, logistics, materials, value chain…) need to be handled as well.
- Update courses. Since AM-technology is evolving so fast, AM-skills quite quickly become outdated. People should be able to follow update courses, without having to go to a full education cycle.
- Enough and predictable quality. This is perhaps the most difficult requirement. There are simply not enough skilled people at this moment that includes teachers and trainers. This is a chicken-and-egg problem. On top of that, there are quite a lot of self-proclaimed experts, teaching and giving consultancy with varying quality levels. This is mainly due to the fact that the technology is relatively new. Moreover, there is an uncontrolled growth of different courses, which are not comparable. From the perspective of the one seeking further training in AM it is not clear, which courses are available and which ones are of high quality and recognised on the market. Therefore we need a standardisation of further education in AM to create a transparent qualification system with comparable courses, which are aligned to industrial requirement and recognised on the European market.

These are the main demands from industry for the SAM-ERASMUS+ project.

2.2 The SAM-ERASMUS+ set-up

The structure of the complete SAM-ERASMUS+ solution is not yet carved in stone but there are some basic blocks that are already clear. The key element within the SAM-ERASMUS+ project to meet the requirements (especially with respect to keeping it up-to-date) is the European AM observatory. The traditional approach of educational institutes for keeping courses up-to-date is reactive to the market demand. In the best case, the institute combines education and research (e.g. universities) and monitors de facto the state-of-the-art in scientific and technological developments. This enables them to keep their educational material up-to-date in their specific area of expertise.

The SAM-observatory uses a different, proactive approach. One of the most important assets of the observatory is the AM-timeline for 10 years in the future. The timeline is based on expert knowledge and existing and planned research activities in AM and related technologies and markets. There are two potential problems with that:

- The timeline is based on predictions and extrapolations by experts. This is however no certainty that the predictions (especially the long term over five years) are correct.
- As time progresses, the term of the predictions becomes shorter.

Both problems are solved by regularly updating the timeline based on reality (catching up with the predictions) and new insights. The update frequency should at least be yearly but can be shorter if important events occur.

Based on the timeline the skill needs can be kept up-to-date and the educational programs can be adapted accordingly. There is (or will be) a whole process implemented to adapt the educational material (courses, trainings, internships…). And the material will be spread over the network of European stakeholders (educational institutes, industry, standardisation bodies, governments…).

This way of working ensures the courses to stay up-to-date. The differences between the different educational institutes become smaller (if not standardised) providing a predictable quality. Furthermore, it becomes easier to *train the trainer* so the total offer can be increased.

Since the delta's of the state-of-the-art/timeline are monitored, it should be fairly easy develop *delta courses* or update courses.

Because of the close monitoring and the inclusion of the predictive models of the complete AM landscape, all information is now centralised. It becomes easier to classify the different technologies and the related skill needs and to keep track on the students and AM professionals. This can be used to determine the boundaries between the different skill sets and offer relevant modules of education.

Going beyond the mere manufacturing is not ensured by the structure of the observatory and will be a constant point of attention. In a first phase, the AM technologies will be monitored by the observatory. In later phases, this can be extended with the other aspects of AM: the impact on design, the business models, value chains, logistics, legal aspects...

The following videos available at the project website provide a good insight into the project goals:

- AM Observatory
- AM Qualification System