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Recommendations on the development of a Portuguese knowledge base in Metal Additive Manufacturing (MAM)

Jaime Bonnín Roca

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Metal Additive Manufacturing (MAM) holds the potential to transform manufacturing in sectors such as the molds industry, where Portugal has traditionally been a global leader, or aviation, an industry which has received increased institutional support since the establishment of Embraer in Évora in 2010. However, findings from my research suggest that at present Portugal lacks the institutional and human infrastructure to support the widespread adoption of MAM technology.

**Key observations:**

- Underinvestment in MAM could mean a loss of competitiveness in the long term.
- The Portuguese higher education system has neither enough equipment nor sufficient know-how to supply graduates with MAM-related skills.
- Portuguese firms and intermediary organizations are reluctant to invest in MAM.
- The current structure of EU Structural Funds imposes severe constraints on the promotion of emerging technologies.

**Policy recommendations:**

- Promote the creation of multisector public-private consortia to share equipment and accelerate the awareness of MAM’s potential nationwide.
- Increase the scope of existing international partnerships to access world-class MAM skills.
- Renegotiate the conditions of the Structural Funds for the next Framework Programme, to achieve flexibility to promote MAM in Portugal or, if that is not possible, create a Portuguese national pool of funds for the promotion of technologies such as MAM which could be considered ‘strategic’.

MAM offers the possibility of creating complex and lightweight components, dramatically reducing development times and the need for inventory. These advantages are critical in an industry such as aeronautics, where small weight savings translate into important fuel savings in the long term. In fact, the first MAM parts are already flying. However, the application of MAM in aviation is still limited to a few applications by the major OEMs and a handful of defense contractors. The absence of aircraft-grade standards hinders the adoption of MAM by Portuguese
suppliers, which would have to engage in lengthy and costly development program to enter this market. Portuguese companies such as OGMA and TAP hold a strong position in the Maintenance, Repair and Operations (MRO) market. Players in the MRO market see MAM as holding the possibility of reducing their investments in equipment and the need to maintain expensive inventory. However, it is still unclear how MAM will be regulated and, at least in the short term, OEMs are trying to capture the MAM aftermarket.

To date Embraer’s investments in MAM have been modest and late, as compared with other industry players such as Boeing and Airbus. Furthermore, Embraer’s exploratory MAM projects are localized in Brazil, and to the best of my knowledge there no plans to install MAM technology in the Évora’s facilities. However, Portugal offers two advantages over Brazil to develop MAM technology: first, Portuguese firms do not need to pay tariffs to import MAM equipment, while Brazilians do; second, Portugal has access to highly skilled labor from across the EU. Acquiring equipment and creating MAM-focused training programs at the recently opened engineering center in Évora may incentivize Embraer and other companies in the aeronautics cluster (which may also manufacture components for Boeing and Airbus) to gain interest in the technology. At this point, and until Portugal has developed stronger MAM capabilities which can compete against the leading countries, the country will likely need to acquire foreign labor to impart the training.

In light of these limitations in the aviation industry, Portugal would be well advise to also explore MAM opportunities in other industries so as to start developing MAM capabilities in application domain that involve higher risk tolerance and lower barriers to entry. For instance, MAM might be instrumental in helping Portugal to retain its global competitiveness in the molds industry. Furthermore, the largest players in the molds industry are already low-tier suppliers in the aeronautics industry. Other players which could exploit MAM advantages are the machinery industry and the manufacturers of tungsten tools. In addition, MAM is becoming a widespread technology in the manufacturing of customized medical implants, a field that also has a more favorable regulatory environment than aviation. Currently, there are no Portuguese companies producing implants (other than dental). Adopting MAM in this area might bring an opportunity to reduce imports.
My findings suggest that there are two important barriers to the development of MAM capabilities in Portugal. The first barrier, and probably the more important, is the lack of MAM-specific formal training. Currently, the Portuguese higher education system is not able to provide graduates with basic MAM skills. Most MAM researchers started their work in the late 1990s or early 2000s within the scope of the Rede Nacional de Prototipagem Rápida (RNPR), but discontinuities in the funding programs and the lack of investment in new equipment led to a situation where there are not formal mechanisms to create a new generation of MAM scientists. Students at engineering schools are barely exposed to a technology which is the center of attention in other European countries such as Germany, the UK or Belgium. MAM is unheard of in professional training centers, while it is already being introduced at community colleges in the USA. Portugal has been a leader in developing graduate programs with some of the world’s leading engineering schools, including Carnegie Mellon University. To reduce this gap in education and training, Portugal should give serious consideration to using those associations to leverage those existing international partnerships to access world-class education in the field of MAM. However, doing that will alone will not be enough. If Portugal wants graduates with MAM skills to return to the country after completing their degrees, there the country (and its firms) will need to invest in MAM equipment and the development of MAM-specific curricula. The opportunity to obtain such top manpower may facilitate the inclusion of Embraer and other leading aero companies in international projects and grants, thus creating job opportunities in Portugal for the new graduates. Furthermore, in order to accelerate the diffusion of MAM knowledge, the Portuguese Science Foundation might want to further promote opportunities for ‘professional’ dual degree PhD programs, in which students develop their dissertation work within the context of a particular sponsoring company.

The Portuguese industrial landscape is dominated by SMEs which have neither the size nor the talent required to perform the type of internal R&D that MAM requires. Industry associations and technology centers, who are theoretically the actors in charge of developing technologies in a pre-competitive stage, have shown until very recently little interest in creating MAM research programs, due to their lack of know-how and the level of uncertainty surrounding MAM technology. To ameliorate these problems, I recommend creating consortiums with members from academia and different industry sectors, where members can share the equipment and thus lower operating and R&D costs. Consortiums such as RNPR have been very successful in the
case of Polymer Additive Manufacturing, but they were discontinued before MAM reached a stage of maturity where industry could feel comfortable investing their own funds.

Another barrier which affects not only MAM but any emerging technology, is the structure of Portuguese R&D funding schemes. Currently, funds managed by COMPETE are completely dependent on any changes made at the EU level. Funds also present important different geographic restrictions which restrict the availability of funding in Lisbon, the region which produces the largest number of university graduates, and which lately has become one of the most attractive cities for entrepreneurs. The need for changes in the way how Structural Funds are used for Science and Innovation purposes has recently been brought to scene by the so-called ‘Lamy Report’ (Lamy et al, 2017), opening a window of opportunity for the Portuguese government to remove geographical restrictions which hurt technological development in the country.

While Portuguese firms may seek funding from Horizon 2020, in the case of MAM they are likely to have a hard time competing against companies in other European countries which have much more developed MAM capabilities. In addition, Portuguese intermediary research institutions have little incentive to work in research projects that offer little immediate financial return. This likely explains why most have remained largely unaware of the details of international development of MAM. To overcome this second barrier, the Portuguese government may want to consider the allocation of a small pool of Portuguese funds, not subject to the restrictions of the EU Structural funds, to the development of technologies which are considered ‘strategic’ to the competitiveness of the national industry. A portion of these funds could be used to provide base funding to intermediary organizations and incentivize them to participate in long-term projects.

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**References**
