Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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ADDITIVE MANUFACTURING AS TOOL TO SUPPORT SUSTAINABLE DEVELOPMENT

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Abstract: *Additive Manufacturing (AM) has been available in South Africa since 1991, and went through all "new technology trigger trends", into productivity. "Productivity's" here goes beyond the effective and repeatable production of a wide array of products in different materials. It also refers to batch production as needed, in any configuration of design for X. The paper reflects on the development of a sustainable research and development (R&D) and technology transfer (TT) facility in a "remote" location, and the very effective performance in supporting sustainable economic development, while effectively integrating government-funded R&D programmes. Examples of successes in general and specialized product development in the medical, tooling and production areas – all in support of new venture creation will be used to discuss the development path followed in SA through a triple-helix approach.*
Key words: *Additive Manufacturing; Triple Helix*

1. INTRODUCTION

AM was introduced in SA in 1991 (Wohlers, 2010). Its availability initiated research at some Higher Education Institutions (HEIs), followed by more, as successful research applications grew. Uptake advanced rapidly, especially within industry, and SA can provide valuable benchmarks (Campbell et al., 2010). HEIs also have a "public life" and must make social contributions through knowledge creation, and to make knowledge, underlying expertise and infrastructure available through partnerships with industry, commerce, and community (Moutlana, 2009). AM's introduction through research and TT created opportunities for HEIs to take a multi-, inter- and trans-disciplinary (MIT) approach, and allow HEIs to act as new generation universities that can respond to changes in the knowledge economy (Louw, 2008). Such institutions are capable of different approaches, e.g. offering its programmes under a broader, integrated focus of serving society and their immediate communities. This supports the idea behind entrepreneurial universities (ENUs), explained by Formica (Formica, 1996). In SA, the Centre for Rapid Prototyping and Manufacturing (CRPM) at the Central University of Technology, Free State (CUT), proved that enabling RM platforms can create the platform for HEIs to operate as ENUs.

2. LITERATURE REVIEW

Formica defines traditional universities as having "Invisible Walls", incompatible with companies, as they often are a means to help individuals to achieve their purpose only. ENU's however, foster interaction and networking in the same way than firms do, within a social network of scientists, economists, financers, etc. It allows leveraging between activities and across various sources of funds. As such, ENU orientation is conducive for:

- *Harvesting fruits of university research in the market place;*
- *Outlets to students (internships, jobs, entrepreneurship);*
- *Commercialization of know-how and innovation by students, graduates and staff) or capitalizing on business development realized by other potential entrepreneurs;*
- *Setting up campus companies where the university might retain a major stake in the firm for a while;*
- *Research Funding;*
- *Develop, manufacture, and market in-house technologies.*

Literature often refers to exploitation of academic knowledge, and "depicts" industry as customers seeking only outputs that lead to specific applied research contracts. It wrongly "forces" HEIs to "*patron*" industrial partners or to turn into "technological supermarkets". The aim is to rather be ***applicable*** to industry. Companies often would invest to acquire insight and understanding of academic research once their ability to assimilate research advances is reinforced by entering into meaningful dialogue with the HEI. Formica explains that traditional HEIs have developed a linear model for transferring its basic research to industry (Figure 1).

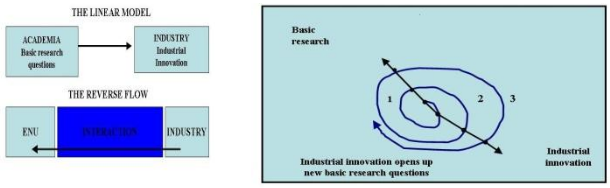

Fig. 1. Reverse Flow and spiral of knowledge transfer (Formica, 1996)

The ENU replaces the law of unidirectional causality with that of circular causality (Formica, 1996). Within the ENU ecology, non-linear feedback links basic research to industrial innovation, and enhances performance. This amplifies the virtuous cycle, and a spiral model with reverse flow from industry to basic research characterizes the ENU (Etzkowitz, 1996). Following Faraday-style behaviour, ENU communities create connections (***partnerships***) with markets generating demands for ***new products or services*** (Formica, 1996). In such institutions, companies seeking a fresh approach to marketing strategies have access to technological innovations (window to new technologies) and technical expertise (brain power). ENUs offer awareness of selected technologies (*i.e. technologies that that can contribute to raise the company's competitiveness*) such as ***AM***, ***RT***, design automation, etc., within a portfolio of best practices on technological innovation.

3. METHODOLOGY

Various sources of government funding have been used through support of industry funds in an innovative approach to implement triple-helix projects. Hall confirms the need for partnerships in SA HEIs by pointing to the relative wealth of the SAHE system, and asking how publicly owned knowledge resources can best be integrated into a wider knowledge system contributing to the objectives of national and regional development strategies (Hall, 2005). He argues that the potential for an extended role in development is not fully exploited, and sets the need for three-way partnerships (shown in figure 2), effecting knowledge transfer through three channels to balance regulation and incentive in the relationship between the state and the private sector, the translation of universal knowledge to practical wisdom in the relationship between the state and universities, and the conversion of open knowledge to entailed resources in the partnership between universities and the private sector. (Hall, 2005). He states that in pursuit of creating such a triple helix, HEIs develop a range of ***smart interfaces*** with both the state ***and private sector***, promoting effective knowledge transfer, to create a valid social and economic return on public investment (Hall, 2005). CRPM used this exact model to introduce AM platforms and solve real industrial problems while also building an AM research community. Results led to more support, and added operational and infrastructure funding, to position the CUT as a regional innovation centre, in support of local, regional and national economic and strategic development initiatives.

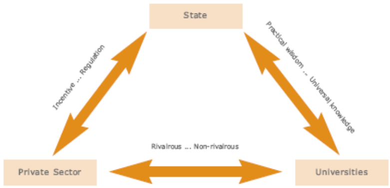

Fig. 2. Three way development partnership (Hall, 2005)

4. RESULTS

4.1 AM Platforms

CUT's AM activities started through a collaborative research project with the CSIR, followed by a 1st investment in 3D Inkjet printing (aka Solidscape). Industry's involvement and funding helped to attract matching government funds. Access to RP equipment at CUT created a better understanding of its limitations vs. industry needs/expectations and created the opportunity to purchase an SLA 250 (3D Systems). As research activities evolved, further limitations identified led to the acquisition of a DTM 2000 Sinterstation. Through active R&D and TT, last mentioned created a chain reaction in industry, leading to purchasing of an EOS P380, EOS P700, EOS M250, EOS P385 and EOS M270X(Ti) respectively – all justified by industry oriented research projects. Concurrently, extensive investments in CAD/CAM and specialized Materialise software were made, to effect medical product development.

4.2 Research and Supporting Programmes

In parallel with CRPM's development, an IPD research group developed, focusing on research in product development related technologies, rapid tooling (RT), rapid manufacturing (RM) and medical applications. These were complemented by a DST-funded Product Development Technology Transfer Station and a FabLab. In Ian Gibson's words, AM became available to everyone! (Gibson, 2008)

4.3 Industry investments and successes

Whereas the first acquisition was made through industrial investment and THRIP supplementation, the SLA 250 and DTM Sinterstation were purchased with university and NRF funding respectively. All the EOS machines were acquired through industrial intervention. One success led to another, and have been reported extensively by De Beer, Campbell, Booysen, Truscott, and Barnard. Papers describing successful applications are: AM development in SA (Campbell et al., 2005), (Campbell et al., 2010); Design oriented support (De Beer et al., 2009), (Campbell et al., 2007), (De Beer, 2002); AM process support (Campbell et al., 2007); Direct Digital Manufacture (Barnard & De Beer, 2007); Innovative Medical Product Development (Truscott), (Booysen et al), (De Beer et al., 2005), (Schenker et al., 1999); Innovative application areas (Agrawal, 2006), (De Beer et al., 2004); and Rapid Tooling (De Beer et al., 2005).

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4. CONCLUSIONS

CRPM's development has shown that any institution, with no prior experience, can create an AM start-up. Furthermore, AM platforms do not need to exist in parallel with existing conventional technologies, or do not need previous success in these. The inverse is possible, since successful projects may create supportive infrastructure. It is also important to note that AM technologies can exist as small factories (factories of the future), as proved within the CRPM applications, and can support innovative projects that in turn can lead to local economic development. CRPM also demonstrated how these technologies can support strategic government initiatives.

5. FUTURE DEVELOPMENT

Extensive R&D supports high-end AM applications in SA, but more (published) research results for 3D printers are needed. Taking into account that 90% of the current SA AM infrastructure is 3D Printers, more R&D in this field needs to be published. AM education and R&D will also receive increased attention through availability of low cost initiatives such as the RapMan, with potential roll-out to schools and small businesses.

6. ACKNOWLEDGEMENTS

The author would like to thank the CRPM and IPD members, NRF, THRIP, MRC, Tshumisano, AMTS, LMDN and TiCoC, as well as all collaborators and industrial partners.

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