

An Intimate Approach to the Management and Integration of Design Knowledge for Small Firms

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In August 2012 the author presented a paper entitled “The Fuzzy Front End of Product Design Projects: How Universities Can Manage Knowledge Transfer and Creation” at the International Design Management Research Conference that year. Via a series of design projects and design support schemes, the paper investigated how a higher education institution with a particular approach to the management and integrating of knowledge on behalf of small firms, could bring together manufacturers, sub-contractors, design consultancies, market researchers, intellectual property specialists, funding bodies and other higher education institutions to make for an extremely effective design support network. In particular the paper dealt with the dynamics of knowledge acquisition during the “fuzzy front end” of product design projects. It was suggested that, through this novel approach, the management and integration of the different players involved in new product development (NPD), higher education institutions could help small firms, in particular, achieve effective knowledge transfer, develop new knowledge and generally reduce and manage uncertainty in the process and therefore utilise design more effectively in generating new products and increasing profitability.

This paper investigates the work that has taken place in the ensuing years including material that led to ‘outstanding impact’ in the 2014 UK Research Excellence Framework (REF) evidencing significant economic growth as a result of this approach to the management of the NPD process for small firms.

The paper proposes that the management and integration of those factors leading to successful NPD for small firms requires an ‘intimate’ style of engagement to be effective; demanding a broad knowledge of, and or an

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ability to manage, those factors pertinent to the needs of small firm. This can be seen as being similar in approach to the 'heavyweight manager' proposed by Clarke and Fujimoto (1991) for larger organisations with 'in-house' NPD teams. Based on four case studies, this paper attempts to identify the nature of this 'intimate' approach and therefore its potential significance.

Keywords: *Integration; Intimate; Small firms*

Introduction

Much has been written in design press and online design related articles recently about the possible current stagnation of design firms and even the 'decline of Agency versus the flexing muscles of In-House design' (Sen, 2015), with consultants such as Smart Design (San Francisco) and BERG closing with other groups like Teehan+ Lax, Adaptive Path, Fjord and Lunar having been adopted by larger institutions (Sen, 2015. Lockwood, T. 2015). We are even witnessing groups such as Frog Design and Ideo being bought and sold like a commodity by the likes of Flextronics and Steelcase respectively (Lockwood, T. 2015). Even the DMI are acknowledging this within their activities (Figure 1).

Good Design is Good Business

*"Design firm acquisitions continue: 42 design firms have been acquired since 2004 ~ 50% of which have been in the last year alone." **

The recent additions by management consultancies like McKinsey and Ernest & Young are an indicator of a growing intersection between design and strategy. How does this development change the meaning of design and strategy within organizations? How is this intersection likely to develop, and what are opportunities—and risks—for design managers?

Figure 1 *Design acquisitions since 2004. Source: DMI (<http://us5.campaign-archive1.com/?u=1a21b525e798e7a71cfd0161&id=eb00e78c17&e=ee031c20de>)*

As McKinsey and Ernst & Young imply, this is not at the detriment of design, far from it; it has long been known that the effective use of design within NPD can have significant financial returns for a company, indeed there are many case studies available to demonstrate this; typically the 10 in the Cité du design, 4 Step/4 Lever Design Management – EN booklet (Bora de Mozata, B. 2015) and the 3 in Innovate UK's Design in Innovation strategy for 2015-2016, which also includes data to support a 20 to 1 increase in revenues for companies where investment has been made in design (Innovate UK, 2015).

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Again as McKinsey and Ernst & Young imply it would appear firms are investing more in design than ever before; GE and IBM have both recently employed 1000 user experience (UX) designers per company and Apple are rumoured to be hiring numerous automotive designers to their team (Lockwood, T. 2015). You only need to look at Lego, Intuit, Bose, BMW, Apple, Philips, Fossil, GE, Starbucks, Microsoft, 3M, Dyson and Nike, to name but a few, to see how investment in design goes hand in hand with commercial success. With all these companies, design thinking at the 'front end' of the innovation process is seen as mandatory and strategically essential (Lockwood, T. 2015). Chiva and Alegre state:

Companies that manage design effectively and efficiently attain better performance than those that do not. Therefore, good design does not emerge by chance or by simply by investing in design but rather as a result of a managed process. (Chiva & Alegre, 2015 p. 424)

The argument for effective design management and the use of strategic "design thinking" as a cost effective business requirement within company business strategy, would appear to have been made. But all these companies are large, vertically integrated firms that manage information in 'a comforting, landscape of abundant knowledge' (Chesborough, 2003 p. XXV), so what about the small and micro SME (Small to Medium Enterprise), where do they currently sit within the design and innovation support spectrum?

In the 2009 study on the incorporation of design management in today's businesses in Europe, over 600 companies were approached to determine the level at which design was used in a 'conscious, systematic or strategic manner' within their companies (Koostra, 2009 p. 11); of these, 24% were large enterprises above 250 employees in number and 53% were under 49 employees in size (Koostra, 2009). Companies were rated on a 4 level scale (1 being minimal engagement and 4 being fully engaged) in each of the following areas - awareness of design, activity in the context of the design management process, design as part of strategic planning, level of design expertise and provision of design resource. In all of these factors, between 38% and 61% didn't make it above level 2 (Koostra, 2009), although it is not clear that it is the smaller companies (SME's) which occupy this space in the evaluations. In fact there appears to be little evidence in general in the literature as to the impact of company size on the relative success of NPD

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(New Product Development) in the early, strategic aspects of the process (Ford and Woudhuysen, 2012), although with regard to construction, Tsortzopoulos, et al. (2006) do refer to the significance and relevancy of a novice or experienced client (company) in the early stage of a design project.

Although it is not explicit there is also a strong implication in the European study that the size of a company and how they rate with these various design management levels is of significance when it states:

High-turnover companies (over 25 million) often score higher when it comes to the level of design management. One possible reason for that is that these companies generally have greater scope for investment in design; and the more a company invests in design, the higher its level of design management. (Koostra, 2015 p. 53)

Although the study does not specifically link a high design management rating to business performance, the 2015-2019 Innovate UK policy would imply this with the 20 to 1 business return on design investment. Indeed the EU design management study does state:

In a number of cases, large companies (more employees) also have higher DM ratings. Company size seems to matter. A large company will have a greater number of specialized departments and complex business processes in place, which increases the chances of them calling in design management specialists. (Koostra, 2015 p. 53)

We know that effective strategic design thinking in the early stages of the NPD process, the Fuzzy Front End (FFE) of innovation is critical to success. Smith and Reinertsen stated:

The true cost of the Fuzzy Front End is much higher than manager's suspect. The most important component of its cost is the cost of delay, not the cost of the people assigned to the project. (Smith & Reinertsen, 1991 p. 53)

Building on this, Hutlink et al (2000) suggest that if a product comes to market six months late but within budget, 33% less profit might be generated over the following 5 years as a result. In a related context, Cooper et al, (2004) suggest that if a product is released on time but 50%

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over budget, profits will be cut by only 5%, and Davis (2002) suggests businesses that can achieve short product development cycles may often outperform businesses with longer cycles. As Bruce and Cooper state (2000), 80% of projects costs are determined in that front-end of the NPD process.

So, where an SME is of a size such that they cannot justify investment in a company based design or a design management capability and address issues in and around uncertainty in the FFE of NPD and NPD in general, it could be argued, that they are very much at a commercial disadvantage.

In 2015 it was estimated there were 5.4 million businesses in the UK alone, 99% of which were classed as SME's employing over 15.6 million people and generating a gross value equalling £1,754 billion, representing a significant proportion of the UK economy (Rhodes, 2015). For manufacturing in the UK this represents approximately 270,000 SME's, employing 1.56 million people and contributing £280 billion to the UK economy (Rhodes, 2015).

Although it is not easy to determine how many of these SME's are at a level where they would or would not readily invest (or indeed have already done so) in some form of company based design provision; given the scale of these statistics for the UK alone, the need to provide effective support for such SME's at the FFE of the NPD process in particular, is likely to be significant.

In these circumstances and in the context of a possibly dwindling consultancy base, is the contracting of design agencies or consultancies sufficient to meet the requirements of SME's of this type, when consultants tend to be briefing orientated and task driven? As Lockwood (2015) suggests:

Strategy, "design thinking," and the customer experience are priorities of corporations not necessarily design firms.(Lockwood, 2015. p. 4)

Similarly Neil Brown, the Creative Director at Insuperity states:

I am not suggesting agencies do not want or do not contribute to a company's success but they have their own bottom line to think of first. (Brown, 2014. p. 2)

And then there is the issue of consistency and the embedding of design and its management within an SME. The designer Nena Mheta states:

For a consultant, projects come and projects go. But, for in-house designers, no project is ever done. Everything is an iteration and there's always an opportunity, somewhere in the distance, to return to a project for another version. (Mheta, 2013. p. 2)

Tsorzopoulos, et al. (2006) emphasize the importance in the effective briefing of consultants which when related to Roy and Potter's (1990, pp. 322,334,335) observations in identifying that small firms, and especially micro enterprises, are 'very much more likely' to either, be guilty of briefing of consultants poorly, or to run into 'severe problems of design management', thus highlighting a problem. However if the consultant is in effect undertaking M/I (Management and Integration) for the SME, then this makes this situation much more efficient.

Whilst there is plenty of anecdotal evidence that implies problems in the SME design consultant relationship, obtaining data from the literature on the effectiveness of SME's utilising design consultancy is problematic. Based on a small sample size Palm and Whitney (2012. p. 8) suggest that 'outsourced product development is not necessarily a disaster', although they do highlight the need to address naturally occurring problems over the entire duration of a project, 'about one third of problems went unresolved'; a situation that consultants are not always able to address financially.

A UK, Department of Trade and Industry (DTI) report on a Government design support scheme in operation in the mid -80's (the Funded Consultancy Scheme) came to the conclusion that this initiative had fallen short of the Design Council's (the Government sponsored funding body) central objective – to ensure that design became 'an integral part of corporate strategy and incorporated at all stages of product development' (DTI Assessment Unit, 1988, para. 9). Later the researchers Roy and Potter were also critical that only a quarter of the 5000 funded projects remained unexecuted or ended with disappointing commercial results (Roy & Potter 1991).

Ford and Woudhuysen (2015) made the following observations:

With manufacturer SMEs, then, publicly funded initiatives that include product design long ago met problems in embedding design, the communications that surround the design process, and the managing of design. So while the state can act as a broker of and a funder for the direct practice of design, introducing manufacturer SMEs to

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design consultants and paying for at least some of their work, these functions alone don't guarantee success in NPD – and, still less, the absorption of design into a manufacturer SME's overall culture. (Ford and Woudhuysen, 2015. p. 66)

A further and significant complication for SME's is the availability of grants, finance and funding. Since the recession of 2008 accessing funding has become far more problematic for all engaged in NPD. For SME's in the UK this is particularly evident; the Innovate UK funded Knowledge Transfer Partnerships (between 66 and 50% funded) that support relationships between Higher education Establishments and companies on R & D initiatives, although successful, is becoming highly competitive and Innovate UK SMART Award scheme for new product development has been discontinued. In a UK, Business Innovation and Skills document (2013), 7 funding support schemes are defined to support SME's with finance. 1 of these have been discontinued, 1 is for disadvantaged areas only, 4 are loan related schemes which are aimed at encourage banks and related channels to lend funding, and 1 is another loan scheme targeted at young people to help start a company.

So despite SME's being fundamental to an economy, it would seem that they are facing a concatenation of difficulties in NPD, these being:

- That there is a proven need for them to embrace and use design and design thinking in their business strategies
- That they are often of insufficient size to justify investment in specialist departments that could provide design management skills
- That there is a reducing pool of design agencies to call upon.
- That design agencies may not be the most appropriate bodies to embed and integrate design thinking and design management within an SME (and provide a legacy)
- That funding is becoming more difficult, more competitive and more time consuming to obtain

So is there an approach or a style of engagement that is appropriate for SME's in this context that can bring about effective and productive NPD?

In the author's paper of 2012, it was suggested that HEI's can play a valuable role in assisting SME's to this end. This additional work considers

how this style of engagement has developed from 2012 and how it has continued to be effective despite reductions in funding opportunities and suggests that it is an intimate style of engagement in the management and integration of design with an within SME's that can lead to product success.

Recap and Further Activity

Recap

The 2012 DMI Conference paper considered the dynamics of knowledge creation during the FFE of the product design process and suggested that through a novel management and integration of the different players involved in the NPD (New Product Development) process, an HEI (Higher Education Institute) can indeed help small firms obtain knowledge, reduce uncertainty and make best use of design in their business strategies.

The paper highlights the role of the 'heavyweight manager' in the work of Kim Clark and Takahiro Fujimoto (1990, 1991) and proposed that an HEI can take on the role of a 'heavyweight manager' for an SME involved in NPD.

The paper was based on three, Government funded, UK, Regional design support schemes proposed, implemented and undertaken by the Design Unit - representing 181 design research projects. In analysing this data it was found that where SME's had worked closely with the Design Unit to **Manage** and **Integrate** (M/I) knowledge and processes in and around the NPD process, there was an 8 out of 10 success rate of product reaching the market and being commercially successful (Figure 2). Where SME's did not wish to work more closely with the Design Unit (in effect, manage projects without M/I support), 9 out of 10 failure rate (Figure 3).

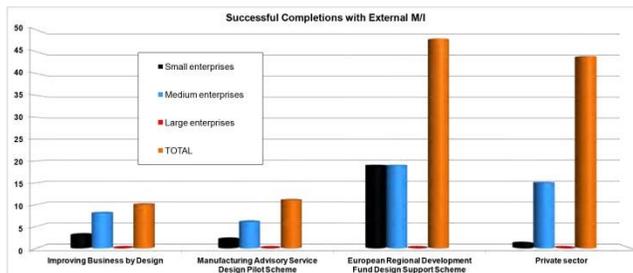


Figure 2 8 out of 10 success rate for SME's with management and integration support. Source: Author (2012, p. 601)

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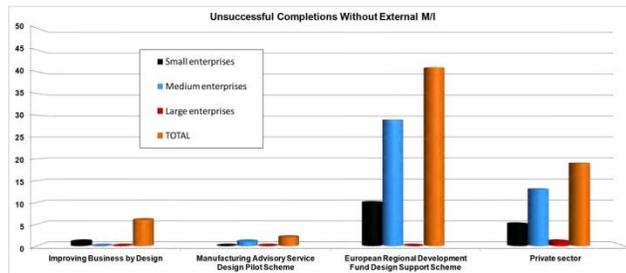


Figure 3 9 out of 10 failure rate for SME's without management and integration support. Source: Author (2012, p. 602)

A conclusion was that that an HEI could indeed manage and integrate the work of various players in the NPD process to the benefit of the client SME, and could indeed effectively fulfil the role of a heavyweight project manager in this context.

Further Activity

Mid 2012 saw the end of the funding schemes that the Design Unit was able to operate as a result of funding obtained from local Government.

From mid-2012 to the present, the Design Unit has continued to undertake projects for LE's (Large Enterprises) and SME's (Small to Medium Enterprise) with a similar continued success. 39 projects were undertaken in this period, 28 for SME's and 11 for LE's. In contrast to the majority of the projects presented in the 2102 findings, all 39 of the projects undertaken from mid-2012 were fully funded from the private sector.

Table 1 presents the key findings from the core data relating to project performance and duration. Massa and Testa, 2008 raise a concern that innovation is often measured on the basis of perceptual self-reported data; the data presented in table is obtained directly from the client companies and refers primarily to products that have achieved a market presence and are generating revenue and creating jobs for the company. As in the 2012 paper it can be seen the LE's generally achieve a more robust performance achieving a 90% success rate of product to market from the projects completed (in keeping with the 2012 findings) as opposed to 70% for SME's. SME's enrolled onto the Design Unit's pre-2102 design support schemes were in some way pre-selected via an application system, this may in some way have filtered out less robust projects, yielding the 80% success,

nevertheless 70% still represents a very creditable statistic and reasonably in keeping with the SME performance achieved prior to mid-2012.

A key statistics would appear to be the number of ongoing projects for SME's compared with those for LE's - 28% as opposed to 9% and the average project duration - 12.4 months for SME's as opposed to 9.3 for LE's. It can also be noted from the core data (not presented here), that of the 8 SME projects still ongoing, 2 date back as far as 2011 and 2 to 2013. When these are completed and added to the statistics the 12.4 month duration is likely to increase.

A further interesting feature is that for both LE's and SME's, around 40% to 46% of projects undertaken were not directly a function of the company's primary activity but as a result of 'spin-off' or other 'growth' activities (see case studies 3 and 4).

Table 1 Headline analysis of the core date of project performance from 39 projects undertaken by the Design Unit, mid-2012 to the present.

	SME	%	LE	%
Total Number of Projects	28		11	
Total Number of Completed Projects	20		9	
Total Number of Ongoing Projects (from total number of projects)	8	28%	1	9%
Successful Projects to Market (from those completed)	14	70%	9	90%
Projects Not Progressing to Market (from those completed)	6	30%	1	10%
Company's Primary Activity	17	60%	6	54%
Company's Secondary Activity ('Spin-Off')	11	40%	5	46%
Average Project Duration - Months (for completed projects)	12.4		9.3	

It should be noted that the Design Unit provides M/I support throughout these periods in order to ensure consistency in project development from inception to completion.

A deduction from this is that SME's quite simply need more time and consistent M/I support (the 'heavyweight manager') throughout these, often protracted periods, to achieve a successful outcomes in NPD.

Tsorzopoulos, et al. (2006) state:

The relationships between the client and the designer and the effectiveness of briefing have been identified within such theories as one of the main contributing factors for good design. (Tsorzopoulos, et al. 2006, p. 2)

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The work of the Design Unit endorses this, confirming that effective M/I relies significantly upon the relationship established at the commencement of project (particularly SME's), but more than this, that these relationships need to extend far beyond just the briefing and the FFE (although critical to the success of a the project) but continue for the entire duration of the project; enabling the co-coordinator for M/I to fulfil the role of 'heavyweight manager'.

Impact

There would appear to be evidence that this approach is successful. In 2005 Lord Sainsbury commended the Design Unit's Improving Business by Design project for achieving a 14:1 return on public sector investment (Sainsbury, 2005) through the development of new markets for UK design and manufacturing companies. In addition, following a 2014 Research Excellence Framework (REF) review of HEI's research outputs including impact case studies, the Design Unit's Design Supporting Business case study was considered as making an outstanding impact on SME's in the Region, generating millions of pounds of increased revenue in addition to job creation (DMU Research Repository, 2016).

The Place of the Design Unit

The Design Unit operates out of an HEI and although there are characteristics of consultancy in how it performs, it is not a consultancy - the work of its staff regularly contributing to the United Kingdom's Research Assessment Exercises for example. Similarly there are characteristics of a Technology Transfer Organisation (TTO) about the way it operates, but it is not a TTO.

Both Siegal et al, 2003 and Kaufmann and Todtling, 2002 argue that there are many shortcomings with the TTO approach, that they do not always meet their objectives and act more as transfer of information organisations as opposed to providing knowledge transfer. Indeed Siegal et al, 2003 argue that HEI's should act as managers and integrators of innovation delivery.

Kaufmann and Todtlington, 2002, advocate a proactive consultancy to address strategic organizational and technological weaknesses within a company. Although Massa and Testa, (2008) contest the need for this, the Design Unit does appear to be effective in achieving successful support in

this manner, acting as a 'nurse' to the SME in this respect, helping them make 'incremental innovations' as Massa and Testa describe it.

In this manner the Design Unit would appear to be effective in making the tacit nature of design explicit to SME's, embedding a design culture within those companies engaged (Borja de Mozota, 2003), and as Kaufmann and Todtlington describe, provide knowledge transfer on a 'learning-by-doing', 'personal face-to-face' basis acting as a 'knowledge provider below the scientific level'.

Acklin and Hugentobler, 2007 refer to design support schemes that cater for large numbers of beneficiaries at a relatively low level of engagement through to ones that provide a customised approach to a small number of clients, arguing that assistance should move beyond individual assistance at project level.

The Design Unit acts as a manager and integrator of innovation delivery, providing an intimate approach to SME (proactive consultancy if you like) business support that caters for the heterogeneous nature of this industry sector by providing direct design assistance; overall supporting a wide range of SME's at a deep level of engagement for what can be relatively long periods of time.

Case Studies:

The Design Unit's research has provided further evidence that LE's are generally more likely to succeed with the NPD cycle based on their own resources, therefore an LE case study has not been included as part of these observations. The following four case studies are all from SME's, the first two are from micro SME's with very little capacity for NPD, the second two being with larger SME's who's core business inspired and or created a 'backdrop' for the development of a new product. In all cases the Design Unit provided various levels of M/I (Management and Integration) support (dependant need) and in all cases worked closely with the client from the inception of the product to market release and or clinical trials) and are provided as examples of the Design Unit's approach to supporting a heterogeneous group of SME's. The case studies provide an opportunity to compare and contrast approaches to assisting these companies based on company configuration.

Case Study 1 – Child Safety Product (Company CSP)

This product was initiated by a husband and wife team (CSP) who approached the Design Unit in February 2005 to assist them in their NPD process.

The product provided a method of linking young children (typically nursery school age) together in pairs (2 to 6) to assist nursery supervisors in taking these children on walks more safely (Figure 4).



Figure 4 Company CSP, child safety device. (image by kind permission of Walkodile Ltd)

CSP had already applied for a patent (IP) on the approach (which did set an initial restriction on the process) but otherwise they had little idea of how to develop a complex product and take it to market. Funds were limited as they were largely dependent on income from their 'normal day jobs', although they did eventually secure some development funding from Scottish Enterprise in addition to investment from friends and family (having working prototypes helped secure this). Considerable passion for the product and a commitment from both CSP and the Design Unit was evident at all times to see product through to success.

CSP had identified the initial product concept had commenced the patent process, the Design Unit undertook the design development and oversaw the production of a series of prototypes (of increasing accuracy and complexity) through to a working prototype for detailed evaluation by external bodies. During this time CSP was charged with doing all of the 'running' and the financial procurement of all concerned as and when required. The Institute of Consumer Ergonomics (ICE) and the Royal Society for the Prevention of Accidents (RoSPA) were contracted/consulted to critically evaluate designs and eventually SATRA Technology to destruction test both prototypes and production items.

The Design Unit sourced appropriate manufacturers in the UK (for ease of communication) and worked closely with CSP and the manufacturers, overseeing the perfecting of early production sample through to full production product.

Generally all parties collaborated and integrated well throughout the project.

During this development time CSP had been making considerable effort to determine a potential sales pipeline including and internet presence; production product being available January 2008 (a **three year development cycle**). During this time approximately £200,000 had been invested in IP, design, tooling and market research. £30,000 was secured from Scottish Enterprise; the rest was from CSP (a major factor influencing the project duration).

Despite the three year development period the product has been a success, prior to product launch in 2008 it had already accrued 12 national and international design awards and in 2011 it was instrumental one of CSP being awarded an MBE form the Queen for services to child safety.

From 1 employee and a modest annual turnover of about £75,000, CSB is now a successful business employing 4 staff having an annual turnover of over of around £250,000 and has expanded its product range to 8 products – the Design Unit having assisted with these on occasion.

Ironically cost had always imposed a restriction on sales due to the products complexity (as dictated by the patent application), the original product (having achieved significant market presence for CSP) is soon to be superseded with a lower cost, simpler product, but without the original design, CSP would not have the significant product and market sector experience to allow them to develop the product nor the confidence to invest further.

Case Study 2 – Self-Emptying Leg Bag System (Company SLB)

SLB (a 1 person company at that time) approached the Design Unit late 2008 with a basic rig for a self-emptying leg bag system for sufferers of urinary incontinence (Figure 5).

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Figure 5 Company SLB, self-emptying leg bag system. (image by kind permission of Albert Medical Devices Ltd)

The design centres on a urine collection bag that can be mounted on the leg and which contains a level indicator and a pump, both of which are attached to a waist mounted controller. When full the level indicator discretely warns the wearer that the bag requires emptying. The wearer can then conveniently pump the bag empty thus reducing the need to re bag on a frequent basis thereby improving the quality of life for those suffering from this condition.

The Design Unit worked closely with SLB to develop the product and oversee/direct the production of a number of working prototypes for initial filed trials.

In mid-2010 the SLB product won the Lord Stafford award in the Innovation Collaboration category. Following this the prototypes proved successful in securing investment funding from a company who wished to collaborate in developing the product to market. As this company was a manufacturer they were able to undertake the required injection mould tooling and related developments, the product being launched at Medica 2011; overall a **three year development period**.

After months of clinical trials 4 staff are now employed in producing the leg bag system which is now sold into 3 countries, SLB now have an initial annual turnover of £150,000. SLB is now continuing to work with the Design Unit on an enhanced device.

Case Study 3 – Wi-Fi Enabled Food Temperature Probe (Company WTP)

WTP are a 'spin-out' of a parent company that specialises in training companies (restaurants, hotels, etc.) in European food safety standards.

Related to this function the company identified a need (and therefore an opportunity) for a range of Wi-Fi enabled hardware devices that could automatically relay food safety data to a Web system. So convinced were they in the product potential that they formed WTP.

Having absolutely no experience in NPD, WTP approached the Design Unit in late 2012 to develop the central product which was a hand held, Android powered, Wi-Fi enabled temperature probe (Figure 6).



Figure 6 Company WTP, Wi-Fi enabled food temperature probe. (image by kind permission of Navitas Digital Food Safety Ltd)

The Design Unit worked closely with WTP to establish the fundamental concept of the probe, essential to which was the need to identify an appropriate display (Android) and a developer of related electronics, firmware and software – which the Design Unit was able to source. WTP sourced a developer for the graphical interface and Web site through which data would be uploaded from the WTP devices and undertook all the sales and marketing activities.

Prototype development progressed through the usual iterations, and injection mould manufacture was sourced again by the Design Unit, the system was launched at the Hotel Olympia in May 2014.

Following a development of a number of related Wi-Fi enabled sensing and transmitting devices (for monitoring temperatures within freezers and fridges etc.) and field trials for the system, the product was fully launched to the market early in 2016; again a **three year development period**.

WTP's parent company had been in business for 29 years and currently employs 24 staff with an annual turnover of £1.4 million. WTP now employs 3 staff and has a projected turn over for 2016 of £500,000. Development

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costs for the WTP system to date are estimated at £390,000, £20,000 of which was secured in innovation grants.

Case Study 4 – Xenon Re-Breathing System (Company XRS)

XRS was founded in 2004 when they set out to become a global of medical technology for critical care, operating theatre and other applications. Their mission being is to provide high quality innovative products to patients and caregivers around the world that help to improve patient outcomes and efficiencies of healthcare organisations with patient focused customer service and technical support. In the early days this involved XRS identifying products from other manufacturers that fulfilled a need and supplying, servicing and providing repeat disposables for them.

As this brought XRS into close proximity to clinical services, they were able to identify when leading clinicians had ideas and developments for new products in their infancy and could see opportunities for NPD from which they could generate their own products resulting from these collaborations.

Their first venture into NPD was the development of a Xenon re-breathing circuit (Figure 7), a product that manages the delivery of Xenon gas and the removal of CO₂ to and from extremely premature babies to help minimise the risk of potential brain damage.

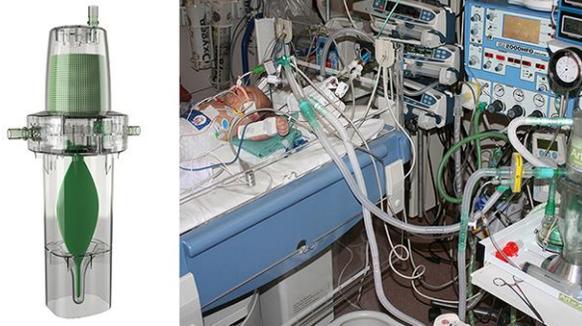


Figure 7 Company XRS, Xenon re-breathing system for neonates. (image by kind permission of Neuroprotexon Inc)

XRS approached the Design Unit for support in 2011 to design and develop this circuit in consultation with their clinicians. The Design Unit worked with XRS to produce 200 prototypes using a rapid prototyping technique (to avoid initial, significant manufacturing investment), but which

would satisfy regulations and conformance for clinical trials. In addition these prototypes were developed with manufacturing in mind (so that re-design would not be required at a later date). Electronics monitoring of Xenon, O₂ and CO₂ was also critical in the development; the Design Unit was able to direct XRS to an appropriate sub-contractor and overall perform the M/I role. Within 18 months the prototypes were on clinical trial, the results of which have been very encouraging to date; trials are still ongoing.

In 2013 XRS established its own in-house design and development and regulatory provision and have subsequently developed their own neonate nCPAP device (to help premature babies on a ventilator) and an adult Xenon re-breathing circuit; XRS have continued to involve the Design Unit in these developments in conjunction with their 'in-house' design and regulatory provision.

In 2011 XRS employed 25 staff and had a turnover of £5.5 million. XRS became a Plc in 2015, now employ 65 staff (including 3 designers and 2 in regulatory control) and have an annual turnover of £13.1 million; overall, an extremely successful collaboration and a strong example of effective M/I.

From 2011, XRS has invested over £800,000 in new product development of which £300,000 has been secured from UK innovation grants.

Observations and Conclusions

In all cases these SME's had little to no experience of NPD prior to collaborating with the Design Unit but worked closely with the Design Unit from inception through to completion.

In all cases the NPD process has been relatively lengthy often involving a variety of other players (IP consultants, product testing, human factors, regulation and compliance, marketing, web development, software, firmware and electronics) in the process.

A factor of particular interest is that all these SME's had a parallel activity taking place, providing some level of financial buffer to the process.

It is interesting that this can be compared with the context of the Design Unit itself, although skilled and experienced in NPD (and in particular working with and assisting SME's), they are part of a large University whose core business is teaching and research. Although the Design Unit is financially self-sustaining, this scenario does provide robustness to these activities helping to maintain continuity and consistency in these relationships.

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Although product development times may be lengthy, this approach does yield robust results, combining the efforts of an SME with the skill and experience of a ‘heavyweight manager’, helping to steer M/I consistently over these periods; enabling the SME’s to engage with the process at reduced risk and to embed design and M/I processes within its culture.

The intimacy inherent in these long term relationships has provided the SME’s with confidence to proceed along the NPD route and to see design and design thinking as an integral, embedded activity within their companies, encouraging the generation of further products and even the development of in-house design provision, leading to long term company success.

In all these cases the relationships are subtly different and change over time, Figure 8 outlines a scenario of parallel, flexible integration between an external body (who has a primary core activity) with an SME that has an income or funding stream (or core activity of its own) to support the activity over that period of activity, enabling long term M/I possibilities. In this context this external body can be seen as bringing about ‘specialised departments and complex business processes’ (Koostra, 2015, p.53) on behalf of the SME.

This paper therefore provides further evidence that this long term, intimate approach to M/I in NPD for SME’s can be very successful.

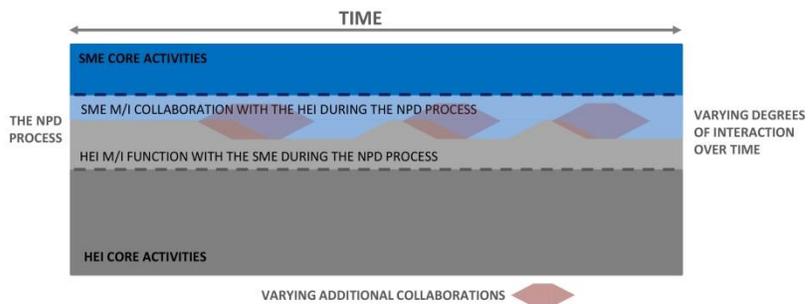


Figure 8 Parallel, flexible integration in the NPD process between SME and M/I provision. Source: Author

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