


Employment-oriented Industry Studies

Resource-based Technology Innovation in South Africa:

Mines and Medicine –Lodox Low-dosage X-ray

K. Gostner

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HSRC Human Sciences Research Council

employment growth & development initiative

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RESOURCE-BASED TECHNOLOGY INNOVATION IN SOUTH AFRICA:

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Produced by: Karl Gostner

Contact: Dr Miriam Altman
Executive Director, EGDI
E-mail: maltman@hsrc.ac.za
Tel: +27 12 302 2402

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1. Introduction

> *We [South Africans] are extraordinarily unsuccessful at converting innovations from academic research into commercial companies (Goldblatt, 2002).*
>
> *The fact is there are many, many good ideas in South Africa that just don't make it (R. van der Watt, interview, December 2003).*
>
> *There are excellent R&D-driven technologies in South Africa that get nowhere (B. Strydom, interview, December 2003).*

This is the story of a South African idea that is in the process of 'making it', that looks as if it might just 'get somewhere'.

The introduction to a story on CNN.com/Health, dated 12 June 2003, reads: 'A digital X-ray system once used to search South African miners for stolen diamonds will now allow Baltimore trauma doctors to scan a patient's entire body in 13 seconds.' This paper tells the story of how this technology was developed and brought to market over the course of the last 13 years.

At the most superficial level it is an outstanding story of how the prevention of theft of a rather valuable stock – diamonds – created a technology that has revolutionised emergency room treatment. At a deeper level it is a story of how a confluence of regulatory and institutional dynamics, together with intellectual networks and personal dynamism, created a unique set of events that led to the emergence of a technology that substantially increases medical staff's ability to save lives.

The Lodox story is a story of innovation, but perhaps more importantly a story of commercialisation, in other words, of the process by which the idea became a technology, which became a product. As will become clear in the telling, the innovation challenge lay not so much in the creation of new technology but in its commercialisation. The initial 'eureka' moment set a series of events into motion, but there were others events that were vital too: if they had not occurred we would not today be examining the innovation in Lodox. It is for this reason that this paper will explore the innovative journey from the sound of 'eureka' echoing through the halls of a South African mining house to the operational use of Lodox in a Baltimore emergency room.

It is hoped that, by both telling the story and peeling back the layers of events, coincidence and personality, this paper will provide some insights into the drivers and facilitators of innovation in South Africa's resource and mineral energy sector.

This paper poses the following questions:

- What were the drivers of the initial innovation, that is, the low-dosage x-rays?
- What provided the organisational impetus to explore the medical innovation that we now know as Lodox?
- What were the institutional, personal and environmental conditions that encouraged the innovation?
- Did government policies and supply-side measures make a discernable difference to the innovation process?

By posing these questions, this paper hopes to advance an understanding of:

- The organisational conditions that foster innovation;
- The processes of interaction between government and the private sector in innovation;
- The extent to which the existing policy and supply-side environment actively foster innovation;
- The relationships between government, academia and the private sector in fostering innovation; and
- The key elements in the journey from innovation to commercialisation.

The paper is divided into three broad sections, the first two of which constitute the bulk of it. The first section describes the events that led to the appearance of Lodox in US emergency rooms. It highlights critical factors that impacted on the development of Lodox. In so doing it provides a context for the analysis that follows in the second section. The second section turns attention to these factors and analyses the way in which they drove and facilitated the process described in the first section.

The concluding part of the paper puts forward some hypotheses as to key variables in the innovation and commercialisation process. It is hoped that in so doing the paper will lay the foundations for a more thoroughgoing analysis of the innovation process.

2. From 'eureka' to 'it's sold'

2.1 What is Lodox?

Simply put, Lodox is a low-dosage x-ray device that takes x-rays both quickly and with comparatively low x-ray exposure. It takes a full body image in 13 seconds; compare this to conventional x-ray procedures, which would take up to 45 minutes to generate the same detail. Furthermore, the conventional approach would generate multiple x-ray photographs of body parts that would ultimately have to be pieced together, as opposed to the single image generated by the Lodox device.

The fast low-dosage x-ray scans that are possible with Lodox could potentially revolutionise emergency-room treatment, as doctors are now able to obtain extremely rapid full-body images of trauma patients, which:

- Provide them with a detailed picture of the patient's internal injuries; and
- Enable them to identify where the patient needs the most immediate intervention.

These advantages, in turn, mean that the survival chances of trauma patients are considerably increased. It is to understanding how this remarkable technology made the journey from South Africa's diamond mines to the emergency room that we now turn our attention.

2.2 The beginning: from Scannex to Lodox

De Beers, the world's leading diamond mining and marketing company, has always struggled to find ways to control diamond theft. Indeed, Brian Ainsley, operations director at De Beers, was quoted in a Sunday Times (25 July 1999) story, 'Rays of Hope', as saying, 'During the '80s, the viability of some of our mines was being threatened by the theft of diamonds.' To combat this stock theft, De Beers used a mixture of physical searches and conventional x-rays. However, in the later 1980s, the International Commission on Radiological Protection (ICRP), a multilateral agency that promulgates international standards on safe levels of radiation exposure, reduced the level of what constituted safe levels of radiation exposure by 80%. In effect this meant that De Beers' ability to search its employees was reduced fivefold. Put differently, the new legislative environment increased De Beers' exposure to diamond theft by 500%. In reaction, the De Beers Research Laboratories were tasked with finding a solution to the risk now faced by the diamond mining industry.

At this point in the story two critical factors enter the equation. The first was Herman Potgieter, who was the catalyst for the think-tank searching for the innovation that became Scannex and who, over time, became the champion who drove Lodox's technological development. For a while he was CEO of Lodox Systems, the company

that today houses the Lodox device, before taking the decision to become Chief Technical Officer, thereby giving himself the freedom to continue focusing on innovation instead of the administration of running a business. The second was the creation of an intellectual community that inspired the De Beers project team to explore the medical applications of the technology that they were to develop.

However, at this stage, i.e. *circa* 1990, Lodox as it is described above had not yet been thought of. The challenge facing Potgieter was to find a low-dosage x-ray device that would enable De Beers to detect efforts by employees to smuggle diamonds out of the mines.

The project team assigned to this problem defined the nature of the challenge confronting them as essentially one of human imaging. They needed to be able to generate an image of the entire human body that would be clear enough for the easy identification of smuggled diamonds. At the same time, this image needed to be generated within the parameters set by the ICRP, in other words it needed to be a low-dosage x-ray. At first, the De Beers team attempted to source technology that would be able to do this for them. Potgieter approached all the major medical equipment manufacturers with a project brief in an effort to entice them to manufacture such a device for De Beers. However, he was unsuccessful, as the manufacturers felt that the market for such an application was too small to justify the R&D expenditure.

After this failed attempt at purchasing the technology, Potgieter then led a fact-finding mission to assess the availability of human imaging equipment and technologies globally. At that stage, he was looking for a technology that could meet three key criteria (Interview: H. Potgieter):

- It had to give a picture of the full body (full body acquisition);
- It had to produce this picture at relatively low x-ray dosages; and
- It had to do so rapidly.

It is a critical part of the Lodox story to recognise that its uniqueness rests in the fact that these three criteria (essential to De Beers in the development of the Scannex technology) had never been recognised as important in the medical world.

This attempt at sourcing led the fact-finders to interact with a whole array of medical experts both internationally and domestically. Among these were medical experts and medical engineering experts from the University of Cape Town who worked at Groote Schuur, the academic hospital associated with the university. It was this group of people who were ultimately to convince the De Beers team that in addition to the security applications of the device that they had invented, there was also the possibility of very definite medical applications. Nevertheless, these efforts too were unsuccessful and Potgieter was compelled to build a team within De Beers to develop the appropriate technology.

The original technology developed within De Beers was able to produce an upright full-body image within the ICRP requirements, and to do so rapidly. This system was called Scannex. Because the system had implications for people's health, De Beers was required to get it medically accredited. This brought Potgieter back to Groote Schuur in about 1995. It was at this stage that the medical possibilities of Lodox were first discussed in earnest.

Professor Gerhard de Jager at UCT captures the dynamic as follows: 'It was really the need to have medical certification that led Herman [Potgieter] to the medical potential of Scannex' (Interview G. de Jager, February 2004). However, for the medical possibilities of the device to be realised, it needed to be re-engineered. Potgieter also explains that 'this was the days before "core business" was a priority, and it was thought that the medical imaging possibilities offered the potential to build a nice strategic business'. It was this confluence of forces that created the space for the conversion of Scannex to Lodox.

2.3 The development stage: enter SPII and the IDC

Inspired by the enthusiasm of Groote Schuur's medical experts and also by the possibility of commercial returns, during 1994–5 the R&D team re-engineered the Scannex device and ultimately renamed it. The new prototype was called Lodox, and was placed in the Groote Schuur trauma unit, where it underwent three years of testing. Prof. Steve Benningfield, head of radiology at Groote Schuur, says that this version later became known – in a somewhat tongue-in-cheek way – as Oldox. He notes that Lodox at this stage 'showed promise, but didn't quite meet the grade'.

It now became clear that further development of Lodox would be required – a cost that De Beers was unlikely to bear on its own, despite the enthusiasm of the medical experts. Accordingly, the De Beers project team applied for funding from the Support Programme for Industrial Innovation (SPII) a programme established by the Department of Trade and Industry (DTI) and administered by the Industrial Development Corporation (IDC) to assist companies in the commercialisation of industrial innovation.

At this stage, three new important factors enter the Lodox story:

- Government supply-side measures, which facilitated further development;
- Bertie Strydom, the Industrial Development Corporation (IDC) manager, who was to become an important champion of Lodox and today represents the IDC on the Lodox board; and
- The IDC itself, which became the first investor in Lodox besides De Beers.

Bertie Strydom describes Lodox at this stage as 'having shown innovation and demonstrated the ability to succeed, but being very far from a commercial operation'. The SPII was the first step down the commercialisation road. SPII is a supply-side measure established by the Department of Trade and Industry (DTI) and

administered by the Industrial Development Corporation (IDC) to assist companies in the commercialisation of industrial innovation. Typically this means assisting in the funding of prototype development. Having secured this funding, the De Beers project team, together with the medical team at Groote Schuur, re-engineered the original Scannex device, and so an Advanced Demonstration Model of Lodox was born.

The Industrial Development Corporation, anxious to secure the intellectual property (IP) rights within SA, then approached De Beers with a joint venture proposal that sought to unlock the capital required to take Lodox to the next stage of development.

However, nine years into the process, with a considerable investment of human and intellectual capital (and the associated costs), and no returns in an area that was not their core business, De Beers were feeling ambivalent about their future with Lodox. Accordingly their priority was to dispose of the business and recoup their investment in its development.

The De Beers management approached all the big original equipment manufacturers, attempting to sell them the Lodox technology. However, they had invested so much in the development of Lodox that the upfront capital costs were too high for a direct purchase and so no-one would buy the technology. De Beers, driven by their desire to generate a return on their investment in Lodox, simply wanted too much – ten million US dollars for the technology. In Potgieter's words, 'It looked like the adventure was over.'

At this stage the relationship with the IDC, which had been forged during their role as the administrator of the SPII funding, became critical. De Beers' desire to recoup some of their investment, together with this relationship and the IDC's desire to secure the technology for South Africa, meant that they were able to reach an agreement that would see the further commercial development of the Lodox system. This agreement laid the foundations for the emergence of a new company, Lodox Systems, which would attempt to further the commercialisation of the Lodox technology.

2.4 An independent company is born

One of the first steps taken by the IDC in its new role as investor was to co-fund a market study and also some actual marketing of the product at international trade shows. In both cases the results were positive, giving De Beers, the IDC and Herman Potgieter – the leader and champion of this technology – the confidence to forge ahead.

As the technology developed, two factors came into play. First, the IDC's continued investment in the refinement of the technology had led to a situation in which its equity was increasing to above 30% – the IDC's maximum threshold for a stake in a company. Second, it was becoming clear that it was necessary to find a partner who understood the medical equipment market. The IDC and Potgieter both felt that the

company would benefit from having a partner that was able to provide input into end-users' purchasing criteria. So started the search for a partner with knowledge and understanding of the medical market.

This search resulted in the entry of a third shareholder into Lodox Systems. This was Netcare Hospital Management (Pty) Ltd, which is a wholly owned subsidiary of Network Healthcare Holdings Limited, Africa's largest private hospital and doctor network. Netcare is the final piece in the explanation that appears in the following section of this paper.

Riaan van der Watt, Group Clinical Engineer at Network Healthcare Holdings, describes Lodox as being 'unique. It addressed a critical part of the emergency room workflow. It meant that x-rays could now happen simultaneous to resuscitation.' This innovation was of critical importance to the Netcare group, a specialist in tertiary healthcare provision, and the operator of some of South Africa's largest emergency rooms.

With Netcare's assistance and expertise building on the considerable work that had gone beforehand, Lodox Systems was able to place its first fully operational unit in Netcare's Milpark hospital, home to one of the busiest emergency rooms.

The major challenge that then confronted the company, and still does so, is penetrating the USA market. The US accounts for over 50% of total sales of medical imaging equipment, and thus success in that country is a prerequisite for success in this market segment. Given this challenge Lodox launched a marketing initiative. The marketing of the Lodox technology at international trade fairs was ultimately to lay the foundations for the opening of a Lodox subsidiary in the USA. This was a critical step in the product's development, as the US is the world's largest market for medical imaging equipment. Following Potgieter's participation in these trade shows he was contacted by William Greenway, who was the engineering head at one of the big and ambitious original equipment manufacturers (OEMs), and Kevin Oakley, a specialist in marketing medical technology, with a proposal to represent Lodox in the US. Thus the first steps towards establishing a US subsidiary were taken.

However, getting access to the USA market required that Lodox receive Food and Drug Administration (FDA) approval. By all accounts, obtaining FDA approval is an exceptionally time-consuming and costly exercise.

Bertie Strydom estimated that the average cost of conforming to FDA requirements is in the order of $1.5 million – a cost large enough to put a halt to many attempts to commercialise medical technology.. Here again, the relationship with academia proved to be essential and Professor Steve Benningfield of UCT drove the clinical trials that underpinned this application. The unique of skills that now constituted the Lodox ensured that the technology sailed through the FDA process in eight months, at a cost of less than R1 million.

2.5 AMI: the Lodox child

Running parallel to the birth of Lodox as an independent company was the creation of a second company, African Medical Imaging (AMI). AMI was created as a joint venture between Lodox Systems, National Accelerator Systems and the University of Cape Town. Professor Kit Vaughn, head of bio-medical engineering at UCT, was critical to acquiring the Innovation Fund support that led to the establishment of AMI.

It had two aims:

- To further explore the medical possibilities of Lodox with a view to advancing the technology's commercial possibilities; and
- To obtain and properly administer government supply-side support, in the form of the Innovation Fund.

Although Potgieter says of AMI that 'in the business sense it was not that successful', the AMI 'experiment' made its contributions elsewhere. Most notably it resulted in 12 postgraduate degrees being awarded to students who had worked on the Lodox project. Indeed, some of these students went on to work for Lodox Systems, and thus the project contributed to the country's intellectual capital.

2.6 Where is Lodox today?

Today the Lodox device is operational in a number of US emergency rooms. The company, Lodox Systems, has established a US sales and marketing competency and in Strydom's words, 'Everyone is now watching closely. The next 12 months will be critical.'

2.7 Summary

In the course of the last few pages, we have traversed approximately 13 years in the history of a technology, a business, the people and the social and institutional processes that led to what is tantamount to a revolution in emergency healthcare provision. This section of the paper has:

- Given a brief synopsis of the milestones in this process; and
- Highlighted the factors that are of significance in understanding the development of Lodox.

We now turn to trying to understand how these various events, role-players and institutions all interacted to bring about the emergence of this new technology.

3. The drivers of innovation

In the first section of this paper, I attempted to highlight what key participants have identified as defining moments in the Lodox story. In this second section of the paper we turn to analysing those moments and their contribution to the innovation process in greater detail. In doing so, we face the enormous challenge of analysing and understanding what drove the development of Lodox, while extracting some themes that may inform a broader understanding of innovation, for, as Riaan van der Watt said, and as will become clear below, 'It was a very very specific set of circumstances that drove this development.' Nevertheless, as the reader will observe from the other case studies in this series, there are a number of general processes that they all have in common. The second analytical challenge that we face is that this story in fact represents a double innovation. First, we have the innovation that led to the creation of Scannex. Second, we have the innovation that transformed Scannex into Lodox. Associated with this second innovation are a series of events, forces and individuals that have been integral to its commercialisation. Much of this next section is focused on the second innovation and the commercialisation processes associated with it.

3.1 Necessity is the mother of invention

Regulatory changes and the risk of diamond theft were the first drivers of this innovation. This could be coupled to the fact that no medical equipment manufacturer has developed appropriate technology to meet De Beers' needs. This initial driver contributed more to Lodox's medical innovation than might be initially apparent. Van der Watt explains the impact that driver had:

To understand Lodox, you need to understand two things. The first was that the principles behind Lodox were not new; it was their application that was innovative. The second is that that innovation was driven by the fact that the De Beers team was working with a very clear objective. They had to generate a good image with as low as possible a dose. This meant they were operating with a completely different set of rules to those that normally applied to x-ray technology. The normal medical rules were that you had to generate an 'as clear as possible' image. As long as the radiation levels were within medically acceptable norms they were not an issue, as it was unlikely that the patient would be receiving regular exposure to x-ray (unlike the mineworkers, who would be x-rayed regularly).

In other words, the initial business driver changed the conditions under which the De Beers project team approached the question of human imaging. Because of these changed conditions, which meant that they had a different set of standards that they had to comply with, they came up with an entirely novel solution. The circumstances under which the De Beers team was operating led them to ask questions and search for solutions to the problem of quick, efficient, low-dosage, high-resolution images in ways that were fundamentally different from those taken by medical technologists in

the same field. Perhaps it is precisely because engineers drove the innovation team in a mining company rather than a medical company that Lodox came into being.

The lessons for innovation are twofold. The first is the self-evident part of the equation, namely that regulatory pressure, risk or any other form of environmental pressure can create the conditions under which innovation occurs. It is probably fair to say that there is no profound lesson for studies of innovation in this first point. However, the second part of the 'necessity' equation is more interesting. As Van der Watt points out, the principles were not new; but the project team was thinking about them in a different context, applying different rules to the medical environment. They were able to generate a unique solution. The changed ICRP regulations created the pressure for innovation, but it was the second aspect, the change in the rules and the context within which one thought about the challenges of human imaging, that led to the innovation, namely Scannex, which become the bedrock of Lodox.

3.2 A liberation of talent

Like almost everything else in South Africa, Lodox appears to have been shaped by our political transition – albeit more obliquely than in other cases. With the demise of apartheid, many of the military-equipment manufacturing firms that had been supported by the state began large-scale retrenchments or simply closed down as the state's defence-related expenditure dried up. As a consequence of these retrenchments, many highly skilled engineers suddenly found themselves on the labour market. Herman Potgieter recalls that the staffing levels of the core team surrounding the development of Scannex went from ten to 150 over approximately four years, as De Beers took advantage of the sudden availability of 'large numbers of extremely smart people' (as Potgieter puts it) (Interview H. Potgieter). The advantages of this sudden availability of engineering were many, but key to both the initial Scannex development and its later conversion into Lodox was the fact that De Beers employed a community of engineers who all had considerable experience in different parts of the development process. Gerhard de Jager of UCT commented: 'If you wanted to do that today [develop Lodox] you wouldn't be able to, because the people simply aren't around.' Thus it seems that the process of political liberation and the subsequent demise of the apartheid military complex unleashed a wave of intellectual resources that in some sense gave Lodox the impetus it needed to carry itself through the initial development phases.

Nevertheless the disruption that occurred was not without negative consequences. Potgieter notes that "although the country maintained some of this talent the vast majority left the country". He tells an anecdote of looking for a specific electrical engineering skill that he knew four South African's had. Every single one that he knew had by the mid 1990s left SA. So, although De Beers (and ultimately Lodox) was able to reap the benefits of the disruption the country probably experienced a net loss of intellectual capital.

3.3 Intellectual communities

The story of Lodox is the story of a series of key events that simultaneously open up the possibility of new relationships, which in turn have added enormous value to the project. In many respects it is the second moment, the moment when the initial contact is converted into a relationship, that is more important to the story than the actual event is.

The key moment–relationship conversion points in the Lodox story have been:

- The initial contact with Groote Schuur to assess whether the technological knowledge for challenge facing De Beers existed created a community for converting Scannex to Lodox;
- The drive to obtain additional funding for Lodox, which converted into a relationship with the IDC in which the IDC became key to the commercialisation of the project;
- The search for new equity partners, which introduced Lodox to Netcare, the company that became integral to obtaining FDA certification; and
- Participation in trade events, which converted into relationships that formed the basis for launching a subsidiary of Lodox in the world's largest medical equipment market, the US.

Thus, when we examine the events in the innovation process we need to be aware that they contain a duality of possibilities, one that pertains to the event itself and a second that holds a whole range of other possibilities that follow from the relationships forged through the event. Indeed it is quite likely that it is in the latter part of this duality that the true drivers of innovation lay.

3.4 The medical community

Lodox's engagement with the medical community is the archetypal example of the duality of event and relationship. Herman Potgieter, himself a key factor in understanding the innovation process, attributes Lodox's progress from the security checkpoint to the emergency room largely to the encouragement, engagement and support that he received from the medical community. Bertie Strydom of the IDC is equally convinced of the importance of the role of the medical community. He calls De Beers' 'discovery' of the medical application 'accidental' and says that it was the relationship developed with medical experts that was the 'catalyst' in the further development of Lodox.

Just as the different context in which the De Beers engineers and designers were working enabled them to see applications that medical practitioners had not conceptualised, so the medical practitioners' own world enabled them to see applications for the security-scanning device that may otherwise not have been pursued by the De Beers team.

In a more abstract sense, it was the interaction of two different intellectual communities that provided much of initial impetus underpinning the innovation. Both intellectual communities saw different possibilities based on their own contexts and it was the meeting of these communities that made Lodox possible.

3.5 The role of De Beers

As important as the two previous variables are to understanding the Lodox story, they are – from one perspective – the least important part of the Lodox story. This is because the interesting part is not so much the technological innovation – in a brief interview Riaan van der Watt mentioned at least three other medical technology innovations that he was aware of – but the fact that the innovation has become commercialised. In understanding this it is essential to understand the role of De Beers. The key actors in this story were unanimous in their opinion that Lodox would not have seen the light of day if it had not been for De Beers' initial involvement in the project. Interestingly, though, the role of De Beers was more complex than simply that of the noble benefactor with deep pockets.

3.5.1 A moment in time

The reasons for the Scannex innovation are quite clear. De Beers needed such a device; no one else had made one, so they had to make it themselves. The interesting question is really why a diamond mining company decided to invest so much time and money into developing Lodox, a medical device.

First, there was space within De Beers for the exploration of the Lodox project. Potgieter puts it as follows: 'If De Beers was as strategically focused as it is today, Lodox would not have happened.' Steve Benningfield captures it slightly differently by saying, 'Those were the days of lots of surplus cash and lots of staff.'

In addition, De Beers saw Lodox as:

- A potentially lucrative project that might generate some returns on the investment in developing the Scannex technology; and
- An opportunity to demonstrate a broader social commitment. As Gerhard de Jager puts it, 'X-raying people is a bit of a no-no. Lodox was an opportunity for them (De Beers) to show a commitment to the "greening" of De Beers.'

Interestingly, De Jager believes that, notwithstanding all these enabling factors, it was Herman Potgieter who ultimately made the difference to De Beers' willingness to pursue the Lodox project. He argues that because Potgieter had established considerable credibility with De Beers' senior management, he was given the space to explore a project that perhaps other less gifted and credible individuals would not have been given. Thus it was the combination of organisational and individual variables that opened the space to further the Lodox adventure.

3.5.2 Intellectual capital

Taking a product from concept to market is a complicated, multi-stage undertaking. In its crudest form it follows a path from idea to concept, to prototype, to an advanced demonstration model, to redesign, to commercialisation and implementation. Inevitably each stage in the development process calls on a whole new set of skills, experience and knowledge. For this reason, the fact that Lodox was being developed by De Beers stood it in good stead, as the core project team was able to draw on a wealth of innovation experience and expertise around them as the project developed. Van der Want notes, 'A project of this nature requires a high level of engineering skill, that in turn needed concentrated time to work on the project.' In its De Beers home Lodox had access to precisely this level of skill. Van der Watt went on to say, 'The crux of the matter is that as an engineer you really need to have been involved in a development process three or four times to create the knowledge necessary to take a product through the entire innovation cycle.' In the De Beers laboratories, Herman Potgieter had access to precisely the sorts of people who had such experience. In contrast, most technology start-ups do not have access to such a wide array and depth of skills and so often founder at a particular stage in the development process.

3.5.3 Finance

De Beers' financial contribution is perhaps the most obvious driver of this process. The terminal illness of most technology firms is brought about by a combination of over-investment in the development process, slowness in getting to market, and, ultimately, choking to death on a lack of cash flow. Because it was part of De Beers, Lodox did not have these problems; as Strydom puts it, 'The development costs were small money in terms of De Beers' overall operations.' Perhaps the costs would have been enough to starve a smaller company to death, but the fact that the development took place in an environment where there was no immediate pressure on cash flow or from shareholders hungry for a return on investment meant that the Lodox team could continue to develop the technology and refine it without too much risk.

Ironically, De Beers' lack of rigour in monitoring the extent of their investment meant that when they ultimately decided to dispose of the technology to recoup their R&D investment they were unable to find a buyer, as (in Strydom's opinion) they 'totally over-valued' the worth of the company.

Because they valued it in terms of what they had put into it as opposed to what the medical equipment manufacturers were originally prepared to offer – keeping in mind that these were the same companies that ten years earlier had thought there was no market for such technology – they were unable to find a purchaser and so were almost compelled to enter a joint venture with the IDC to begin the process of divesting themselves of the Lodox technology.

3.5.4 Summary

A series of events facilitated De Beers' involvement in Lodox, the most important of which were the influx of considerably advanced engineering skills into the organisation, coupled with a greater openness to experimentation than may currently be the case in many organisations that have reoriented themselves to focus on 'core' business.

These enabling factors allowed De Beers to have a profound impact on the development of Lodox:

- By giving the project team access to a whole range of engineering expertise appropriate to each stage in the development process; and
- By removing the immediate financial pressures of cash flow and returns to shareholders that have sounded the death knell of other good ideas.

De Beers continues to have a stake in Lodox, but it is seeking to dilute its interest. Potgieter describes the company's continued involvement as a 'goodwill gesture'.

3.6 Supply-side measures

In the course of Lodox's development the company had access to two supply-side measures – the SPII and the Innovation Fund. Interestingly, in addition to the financial assistance that they provided, both played an important 'signalling' role. In other words, the fact that Lodox was able to access this money gave it credibility both with existing and potential investors and with possible clients.

3.6.1 The Support Programme for Industrial Innovation (SPII)

SPII played a dual role in the Lodox story. After three years of testing the Lodox prototype in Groote Schuur it had become apparent that the product would need to be re-engineered if it was to take the next step towards being a commercially saleable product. At this stage, it seems that the De Beers senior management were already having second thoughts about the medical road that they had taken. The awarding of the SPII facility provided a valuable injection of cash into the project, but equally importantly, it was a vote of confidence in the viability of the product. SPII is only awarded after the IDC has conducted a comprehensive assessment.

Herman Potgieter says, 'I am two-thirds sure that it was the fact that we received SPII that gave De Beers the confidence to go forward with Lodox. It said to them that other people believed in the project.' Over and above playing the role of log-jam breaker, the SPII money also advanced the development of Lodox to a point at which the IDC could get involved in the project, by providing assurance that it had moved beyond the R&D stage and was ready for industrial development. Thus SPII provided De Beers with the security to continue their investment in the technology, and

ultimately it took it to a stage where the product was attractive to other potential investors.

Perhaps as important as the money that SPII brought and the confidence that it created, its location within the IDC added a whole new dimension to the Lodox story. The IDC were the administrators of the SPII fund, but by virtue of their role in industrial development they soon took on a more proactive role in Lodox than simply asking for report-backs on the expenditure of supply-side money. The IDC, through its representative Bertie Strydom, developed a 'hands-on' relationship with the De Beers team leading the development of Lodox. Potgieter says that the IDC's involvement was key to encouraging the further development of the project and providing valuable direction in furthering the commercialisation of the Lodox technology. Strydom describes the IDC's role as playing 'the catalyst of marrying everybody'. Importantly, though, he goes on to note, 'We can only play that role if we know what's out there. I think that 50% of these big companies are sitting on technologies that could be converted into good products.' In this respect the location of SPII within the IDC was a critical decision as it provided an environment within which industrial development is a key organisational imperative. Accordingly, the administrators are interested in more than merely ensuring compliance with the terms and conditions of the fund, but are in fact capable of pursuing the industrial development potentials of the technological innovation, and, in a sense, they have an incentive to do so.

3.6.2 The Innovation Fund

The Innovation Fund was less critical to Lodox's commercialisation drive, as it primarily drove the exploration of new potential, that is, it was trying to break new ground for the project rather than furthering the primary thrust of the innovation and commercialisation. Nevertheless, there are some interesting insights to be derived from examining the role of this supply-side measure in the Lodox story.

As with SPII, it seems that the Innovation Fund provided an important signalling role in the life of Lodox. Herman Potgieter says that the Innovation Fund was 'nice to have', but more significantly he believes that it was 'incredibly important to give us international credibility'.

However, aside from this benefit, it is important to keep in mind that the SPII and the Innovation Fund also have different objectives, with the latter seeking to support collaboration between the private sector and universities with a view to increasing the country's intellectual capital. In this respect, it appears that the Innovation Fund was a success, as it generated a number of postgraduate degrees. Lodox benefited directly from this, as it was able to employ graduates from the programme.

3.7 The shareholders

In addition to the intellectual support provided by the medical community, Lodox's shareholders have been integral to advancing the product from a prototype to a saleable product.

3.7.1 The Industrial Development Corporation

The IDC differentiates itself from many institutional investors in the South African context by the fact that '[i]t has a higher tolerance for risk' (Interview: B. Strydom). As described above the IDC played an integral role both in facilitating the migration of the technology out of De Beers and in introducing new investors to the undertaking. Undoubtedly the presence of the IDC on the South African institutional landscape provided an important exit strategy for De Beers while simultaneously ensuring the continued development of Lodox. One has to ask whether, without it, Lodox would not have simply died a quiet death in the De Beers Labs, given the failure of De Beers' attempts to sell the technologies.

However, the IDC's role was broader than simply that of a provider of finance. As discussed above, its initial role as administrator of SPII and its commitment to the Lodox project gave the Lodox management much-needed moral support to continue tackling the challenges that they faced. Over and above these two roles, the IDC introduced what Strydom calls 'a business urgency'. He recalls that De Beers was characterised by a 'strong R&D mindset', but had less understanding of the commercialisation process. The IDC brought this expertise to the project. Here again we see the 'double movement' of an event or process leading to the emergence of new social, intellectual and business relationships that move beyond the immediate event. Riaan van der Watt says that the IDC's role was 'massive, except for the miracle of Herman convincing De Beers … this was the second half of the miracle. Lodox would not have happened without the IDC's involvement.'

Indeed, it is after the involvement of the IDC increased that market feasibility studies, attendance at trade shows and an aggressive search for appropriate partners become part of the Lodox story. Before the IDC's involvement the story is very much one of prototype development, exploration and improvement. Strydom identifies this as a generic weakness of companies driving technological innovation: 'There is a tendency to over-engineer, to invest too much capital in the development when really you need to get it to market as quickly as possible.'

Thus it was the marriage of the innovation in the De Beers Laboratory with the commercial mindset, expertise and instincts of the IDC that enabled Lodox to take the next step in the commercialisation process, a critical component of which was the introduction of Netcare as a shareholder.

3.7.2 Network Healthcare Holdings (Netcare)

Netcare's involvement brought a valuable understanding of the medical business to the Lodox project, enabling those involved to develop more effective market penetration strategies and was thus a critical element in furthering the commercialisation of Lodox.

3.8 Summary

Both of Lodox's new shareholders have been critical to furthering the commercial viability of this innovation. Undoubtedly the fact that the IDC is slightly less averse to risk than conventional investors is an essential component in understanding Lodox's development, as it is that tolerance of risk that enabled it both to assist in the commercialisation process and to introduce Netcare as a key shareholder. Thus it would appear that having partners that understand commercialisation is an integral part of a successful innovation process.

3.8.1 The champions

The final drivers of this innovation that are worth considering are the people who made Lodox happen. Importantly, there appear to be different champions at different stages of the Lodox story. Their status as 'champion' is in large part derived from the fact that they brought particular skills, enthusiasm or resources to the project at appropriate times.

Undoubtedly the figure that looms largest in this story is Herman Potgieter, the person who drove the original search party that culminated in De Beers' first developing Scannex and subsequently Lodox. His role was that of the archetypal champion, driving the concept and the vision of this new product. His own explanations for his role are his intellectual curiosity and his desire to innovate and to drive a development that he believed in. However, it appears that it was also his credibility within De Beers that gave him the space to be a champion. Gerhard de Jager notes that 'Organisations give you space when you exercise discretion and have technical competence. Herman had established both so he had greater freedom to pursue things.'

Potgieter himself does not cast himself in the champion role, preferring instead to give that mantle to Bertie Strydom. Strydom, similarly, does not accept the title, preferring to explain that all he did was to bring a set of skills to bear at an appropriate time in Lodox's evolution.

Although it is tempting to explain the responses of both these champions as simple modesty, there is an interesting truth in both of them. In the quotation in the section on the Industrial Development Corporation above, Van der Watt refers to the two men as equal parts of the Lodox 'miracle'. Therein perhaps lies the key to the 'championship' role – it is about having the appropriate skills at the correct moment in the company's evolution. No doubt there are deeper and more profound individual

reasons that drive people to adopt this role – in Potgieter's case it was intellectual curiosity, an explorer's mindset – but equally important is the fact that different cycles in the process of innovation and commercialisation require different sorts of champions.

This section concludes the discussion of the drivers that are critical to understanding the evolution of Lodox from a solution to a stock theft problem to an integral part of emergency room treatment. The journey appears to have been characterised both by happenstance and by some systematic pursuit of commercial opportunity. Now that we understand both the Lodox story and how the various elements of the story got Lodox to where it is today, the paper will attempt to derive some potential lessons for innovation, which it may be possible to interrogate further as the RBTC project unfolds.

4. Lessons for innovation

The previous sections of the paper have reviewed the specifics of the Scannex and Lodox stories and have also sought to identify the key drivers of this innovation and commercialisation. In this concluding section of the paper, an attempt is made to abstract from the specifics of the Lodox case to broader trends that may be of use to the development of policy, process and institutions for driving innovation.

4.1 Multiple networks

If anything, this story is one of multiple networks. Because of a particular set of demands, the De Beers laboratory transformed existing technologies in a way that had not been conceptualised by the medical community because they thought about human imaging within a particular set of rules, the rules of their network. The De Beers network had different rules and conventions, which created the space for the original innovation. Their relationship with a medical network ensured that Lodox's medical possibilities were identified and realised. The relationship that emerged with more commercially oriented role-players – the IDC and Netcare – meant that Lodox was able to migrate from technological innovation to product. Each of these networks contributed something unique to the Lodox story, and if either of them had not been present, it is unclear whether Lodox would have advanced as far as it has. So clearly the creation of multiple networks, and the encouragement and perhaps support that they give, appear to be critical to the overall innovation process. We have already quoted Bertie Strydom as saying that there are no doubt many technologies whose commercial potential has not been realised because they are housed within big companies' research divisions. The lesson for policy has to be that if we wish to reap the benefits of technological innovation we need to find ways to foster multiple relationships to ensure that all the possibilities of an innovation are realised.

4.2 The duality of events

In the second part of the paper much was made of the fact that each event in the Lodox story in fact triggered the development of a series of social relationships that became integral to Lodox's development. If we take seriously the above policy lesson, that we need to find ways to foster multiple relationships, then we need to find out what triggers those relationships. In other words, key drivers of the National Innovation process need to guide events with the ultimate objective of building social relationships that may advance the innovation process. There are a number of existing opportunities in the public space; two examples are Trade and Industry South Africa's (TISA's) Export Marketing and Investment Assistance (EMIA) scheme, which sponsors participation in trade fairs, and the DTI's Innovation Awards. Such schemes and a myriad of others offer a platform for the advancement of social relationships or the creation of intellectual communities that ultimately underpin any innovation process.

4.3 The 'signalling' effect of supply-side measures

Indisputably the supply-side measures were a key component in the creation of relationships that fostered the development of Lodox. However, just as importantly, they played the role of signalling to potential and incumbent investors that the project was potentially worthwhile. Therein lies an important lesson for policy processes surrounding innovation. Often the call for support is a call for increased public-sector funding of the innovation or commercialisation process, but intriguingly the Lodox story shows that there are two elements to the supply-side story. Obviously the money is critical but equally critical is the signal that the supply-side provides to investors that a project might be worth investigating. For this reason it seems essential that supply-side support only be awarded after a fairly rigorous assessment process, the nature of which is also communicated to the investment community. This would mean that the award of a supply-side measure was a mark of approval for a project, thus making it easier to obtain private-sector support.

4.4 Institutions matter

For both of the reasons that constitute the 'duality of events' and the signalling role that can be played by supply-side measures, it is essential that supply-side measures and related events are located within institutions that have the organisational skill, capacity and imperatives to advance the project. The location of SPII within the IDC is a critical component in the Lodox story. The relationship forged with the IDC by virtue of SPII ultimately led to the introduction of two new shareholders, who have been critical to ensuring the migration of Lodox out of De Beers. SPII location within the IDC ensured that its role was not simply one of funding but also one of catalysing. It would seem that the process of innovation could be furthered by creating relationships between government supply-side measures and institutions that are able to play an active role in commercialising the undertaking. As Herman Potgieter put it, 'The IDC didn't just give us the money, they were continuously involved.'

Conversely, the Innovation Fund experience, although a substantial success in that it created considerable intellectual capital, seems to have contributed less to the major South African challenge, namely the commercialisation of good ideas. Although it is beyond the scope of this paper, it seems fair to hazard a guess that this may in part derive from its institutional location within the National Research Fund, an organisation that has little experience with the commercialisation of innovative technologies, and little reason to acquire such experience, as its purpose is different. Accordingly, it would seem that if the *raison d'être* of the National System of Innovation is to advance this kind of commercialisation, the system of incentives and rewards should ideally be closely aligned to or linked with organisations that have the desire and capacity to add value to the commercialisation process.

4.5 The money

The key participants in the Lodox case all refer to its uniqueness. The overwhelming sense one gets is that it would be exceptionally difficult to replicate the processes that led to this innovation. One of the main reasons for this is the role of De Beers. De Beers was exceptional in that it provided the process with enormous intellectual capacity, and was also a fairly flexible shareholder, providing the company with strong cash flow. Without this initial support it is doubtful whether Lodox would have made it as far as it did. The policy implications are difficult, because they mean that one needs to find instruments that aid cash flow or enable companies to reduce their financial risk by providing some kind of compensation. The difficulty of this is the risk of supporting harebrained schemes that may never contribute in any way to the creation of national wealth.

5. Conclusion

This paper has explored the development of Lodox from the conception of the idea through to its current attempts at achieving large-scale entry into the USA market. The innovation was driven both by design and by accident. However, what is most apparent is that there are two periods, each of equally critical importance, in the innovation cycle – the initial technological innovation and the long road of commercialisation. The irony is that if too much is invested in the first process then the second process is doomed from the outset.

In closing, I wish to return briefly to the various areas of understanding that we explored through the prism of this case study.

This case has clearly shown that the primary **organisational conditions that foster innovation** are:

- A willingness to explore ideas outside of the immediate core business;
- A depth of intellectual resources that enable the project to advance from one developmental stage to the next;
- The presence of a key individual or individuals that have the passion to pursue the project and, importantly, the trust of their organisations; and
- Broader social relationships that deepen the intellectual base on which the project is founded.

In the Lodox case, supply-side measures played an important role in the **processes of interaction between government and the private sector in innovation**. The most important aspects of this were:

- The introduction of the IDC, which played a critical role in the commercialisation of the project; and
- The signalling effect of the SPII fund, which enabled Potgieter to secure De Beers' continued engagement in the project.

Perhaps the central lesson that emerges from the interaction between government and the private sector in this case is the importance of ensuring alignment between the measures and institutions that can aid the innovation process.

The findings of the case study are unclear as to whether the **existing policy and supply-side environment actively fosters innovation**. In the case of SPII it did not so much foster innovation as further it. The involvement of the Innovation Fund falls more squarely into the 'fostering' environment, as AMI was deliberately structured in order to access Innovation Fund money. In other words Lodox and UCT responded to the policy imperatives encapsulated in that supply side. However, one is left with a

sense that there was lost potential because of the institutional housing of the Innovation Fund. Although it did achieve successes, it perhaps was not as successful as it might otherwise have been.

This paper's final objective was to discern the **key variables in the journey from innovation to commercialisation.** It has discussed each of the key variables for Lodox. It is crucial to recognise that there are a series of 'do or die' moments along the innovation path, and the failure to seize these moments can destroy the innovation, no matter how compelling the idea. Lodox is currently faced with such a challenge as it attempts to build and consolidate a critical presence in the US market. Only if this is achieved will we truly be able to say that Lodox is the Charlize Theron of South African innovation.

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