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Evaluation of Digital Printing Innovation at The Royal Mint



Mike Waite

2134221

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1- Introduction

A range of coins developed by The Royal Mint are coins which feature a colour print on the reverse design that is extremely popular with our collector customers.

The Royal Mint until recently (the last 3 years) had been using Pad Printing technology. This type of printing technique involved the use of a Pad printing machine. It required an operator to manually load 1 coin at a time and cycle the machine, which would index the coin under 5 independent colour print pads providing white, black, and 3 primary colours to produce the image via cliché plates also known as printing plates. These cliché plates after design would need to be made externally with a turnaround time of 6 weeks.

The colours would be produced by the operator manually mixing paints in line with the colours required for the image being produced and this would inevitably lead to large variations in colour for the design over the course of their production.

This along with huge lead times on printing plate manufacture and extended setup costs to align images would lead to huge backlogs in production's ability to fulfil orders. Therefore, disgruntled customers resulted since they often have had to wait for months to receive their order. Some customers who made multiple orders of the same coin could clearly see the variation between the colours produced since they were not dispatched in line with production sequence.

Despite this coloured printed coin was and remains extremely popular, this inevitably led to a strategy to develop more coloured coins but to meet the high demand this produced an alternative technology was clearly needed. The technology that could provide potentially provide the improvements needed was Digital Printing.

2- Analysis

Principle Drivers

Key to driving the innovation from Pad printing technology to Digital printing technology is the ability to meet customers expectation on quality and delivery. The lack of consistent quality with pad printing technology and the long lead times associated with the production of coloured coins using this method are by far the principal reasons there was a need to seek alternative technologies.

Some articles have suggested that sustainability would become a key driver of innovation with the suggestion that becoming environmentally friendly would become a major factor and this would end up lowering costs and generate additional revenue (Nidumolu, et al., 2009).

Though environmental aspects are clearly important, so far as the Royal Mint is concerned, this was not a key consideration to go to digital printing. Specific breakdown of the customer aligned reason above was:

- a) Customer complaints were being received on late deliveries
- b) Customer complaints were being received where multiple orders were being placed but the coins received were inconsistent in colour.
- c) A large backlog for colour coins existed due to the delays which will be mentioned later. This was compounded with a roadmap for multiple future designs to be launched that would increase the requirement for coloured coin massively. With the existing order book already challenging the backlog in orders was set to only increase further.

Overcoming Barriers & Risks

The barriers and risks for innovation culture that were highlighted from this project can be broken down into seven key obstacles, the failings are clearly based on uncertainty around the business direction. Innovation management at The Royal Mint is generally limited to incremental innovation by improving existing processes since this is known technology. Breakthrough innovation is generally seen as a potential lot of invested time and resource for potentially little gain. For coloured coin, The business didn't know how the markets would take to increased coloured coin flooding the market and therefore didn't prepare for the eventual wave of orders that followed.

Lack of Shared Vision or Strategy

The desire to innovate the Coin printing process was borne from the urgent necessity to prevent existing and future customer dissatisfaction rather than any foresighted vision or planned strategy.

There was clearly an ignorant bliss at The Royal Mint to the existing pad printing capabilities which, although production was continually highlighting that the technology capability had reached its limit, these concerns were largely ignored by planning and the Exec team who just responded with increased launches of coloured coin SKUs resulting in higher demand for a technology that couldn't cope with existing order demand.

Short-term Thinking

Digital Printing isn't a generally new technology since it is used in multiple other manufacturing processes, although it hadn't before been used on coin. The idea to adopt the technology for coin had been suggested 2 years earlier before the demand existed but R&D into the subject was felt unnecessary at the time since demand for coloured coin was quite low with coloured coin campaigns limited to annual events such as Remembrance Day and some overseas markets.

The business decision was made later that coloured coins would be a feature of many themed coins that were being developed, the focus was placed on potential profits this would generate; the ability to produce the increased demand was not considered.

Lack of time, both resources or staff

When the decision had been made to begin R&D into digital printing technology for coins there was no dedicated resource available. I picked up the project with an initial 12-week deadline and no available support. I also had 3 other projects underway with expectation that none would fall behind due to this new expectation

Lack of "spec time" to develop new ideas and opportunities

Normal development tools such as creation of a spec that evaluated the criteria that needed to be met and idea analysis such as SWOT analysis or Cost benefit analysis was completely impossible due to time constraints.

Innovation not articulated as a company-wide commitment

Had innovation been seen as an innovation management system, exploration into digital printing might have been identified much earlier on. Part of the innovation strategy would have evaluated shortfalls in capability within the organisation and the necessity to improve colour coin production would have been obvious.

Lack of ownership by senior leaders

The strategy that exists at The Royal Mint is effectively a 5-year aspiration on increasing profit. When it came down to the maximisation of coloured coin to generate increased sales, the exec team felt that innovation into delivering it was a manufacturing operations problem. Insufficient regard was given to the current state of play to achieve the strategy and even less to the gap that existed to be bridged to fulfil it.

Leadership expects payoff sooner than is realistic

Following on from the complete disregard for the gap that existed, focus was placed on production with the expectation to meet financial commitments identified by the shortfall in meeting orders generated. Only when orders were falling further and further into backlog and potential sales were not being achieved, was the realisation a new approach was needed. Sadly the initial support that was offered to operations at the time however was threats to the leadership team members viability to remain in post if the situation did not improve.

Managing the Uncertainty

To understand the uncertainty more clearly the business could have applied Pearson's uncertainty map. This concept is based around uncertainty about ends and uncertainty about means and how digital printing fell on this uncertainty map is as follows:

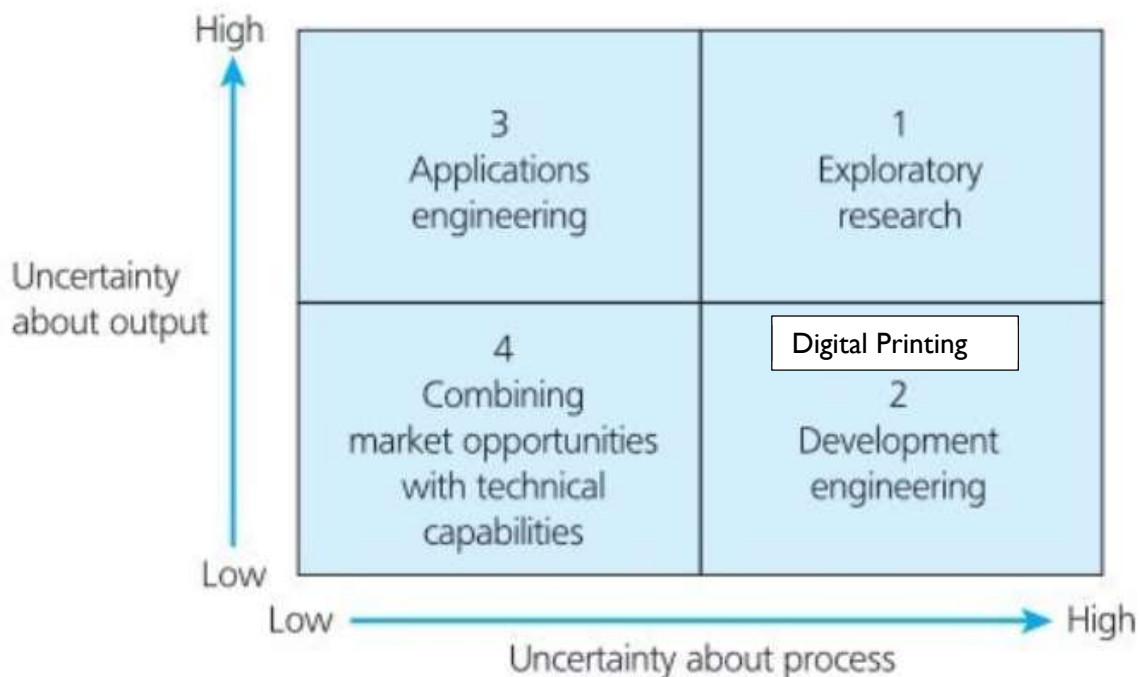


Figure 1: Digital Printing against Pearson Uncertainty Map (Trott, 2012)

We knew what we wanted; a clear printed image aligned consistently with the struck latent image so uncertainty about the Output was low. How we did it and the technology needed to do it we didn't know so the uncertainty about the process was high. What was needed was development engineering and that means we needed an expert to assist us that already knew how this technology worked and who could help us develop a process to gain a repeatable consistent result.

Drivers for the innovation

A paper by Singla, et al., (2018) explored the different strategies to drive innovation suggesting that Technology push adopts the “if we build it, they will adopt it” perspective. While Demand or Marketing Pull is from a recognised need that stimulates innovation via R&D development. They concluded that there is a place for both strategies in a company’s innovation management system, but a company may have a stronger infrastructure that favours one model over another.

As mentioned previously the key driver for this innovation was customer satisfaction so when this is evaluated against the linear models of innovation as to whether this was a technology push or Marketing pull scenario it is clear that the key driver for printing coloured coin was marketing pull.

New Opportunities

Following the successful innovation of coloured coin printing we identified a diversification for the digital printing technology.

Typically, coloured coin is packaged within a themed printed transparent acrylic block, these acrylic blocks were being sent offsite for printing by a printing supplier. Since printing on 3D objects was the technology we now had and understood with the experience gained from development of printing on coin; we felt confident that we would be able to print these acrylic blocks in house.

A new jig was developed to house the Acrylic blocks and The Royal Mint began printing its own in-house acrylic blocks with the first being the Gruffalo coin.



Figure 2: Gruffalo Coin and Acrylic Block (The Koin Club, 2019)

Each Acrylic block cost £2.58 to buy and £2.16 to get printed externally with a minimum order quantity of 15,000 prints and an expected cost to us of under £0.02 per in-house print we were looking at a return on investment for the project at under 2 months and a projected annual saving of over £600,000.

Looking at the printing of the Acrylic blocks against Pearson's uncertainty map we can see that Acrylic blocks now sits in quadrant 4 – Combining market opportunities with technical capability, since the uncertainty of output remains low but with the gained knowledge of printing coin the uncertainty of the process was also now low

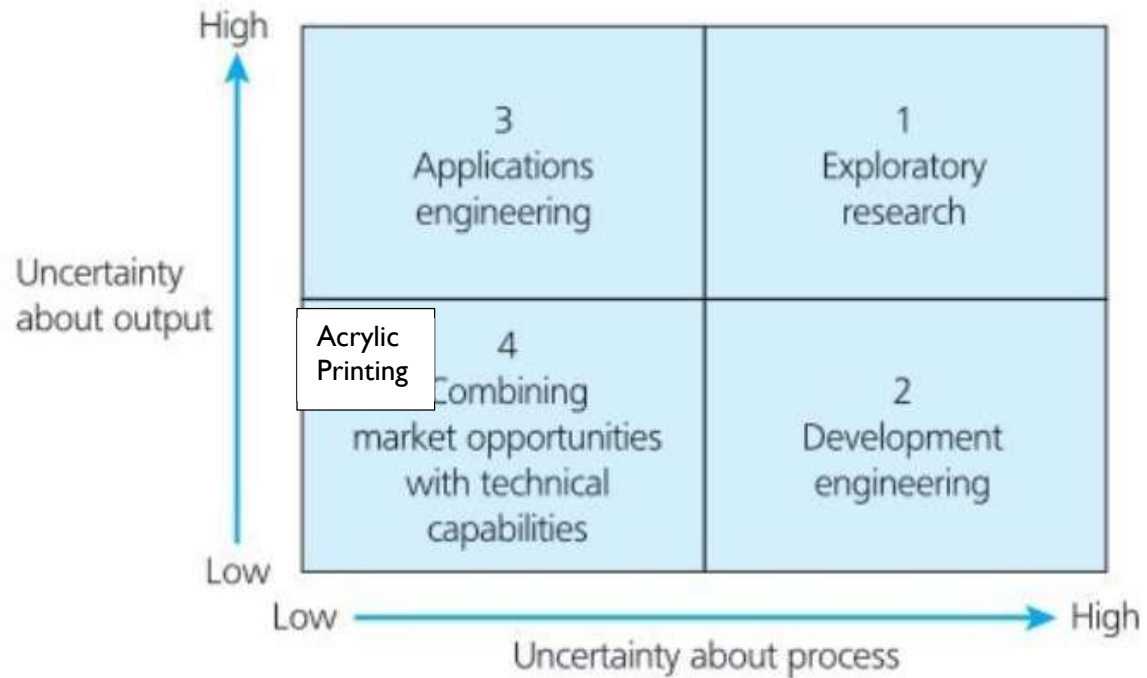


Figure 3: Acrylic Block Printing against Pearson's Uncertainty Map (Trott, 2012)

Processes and Technologies

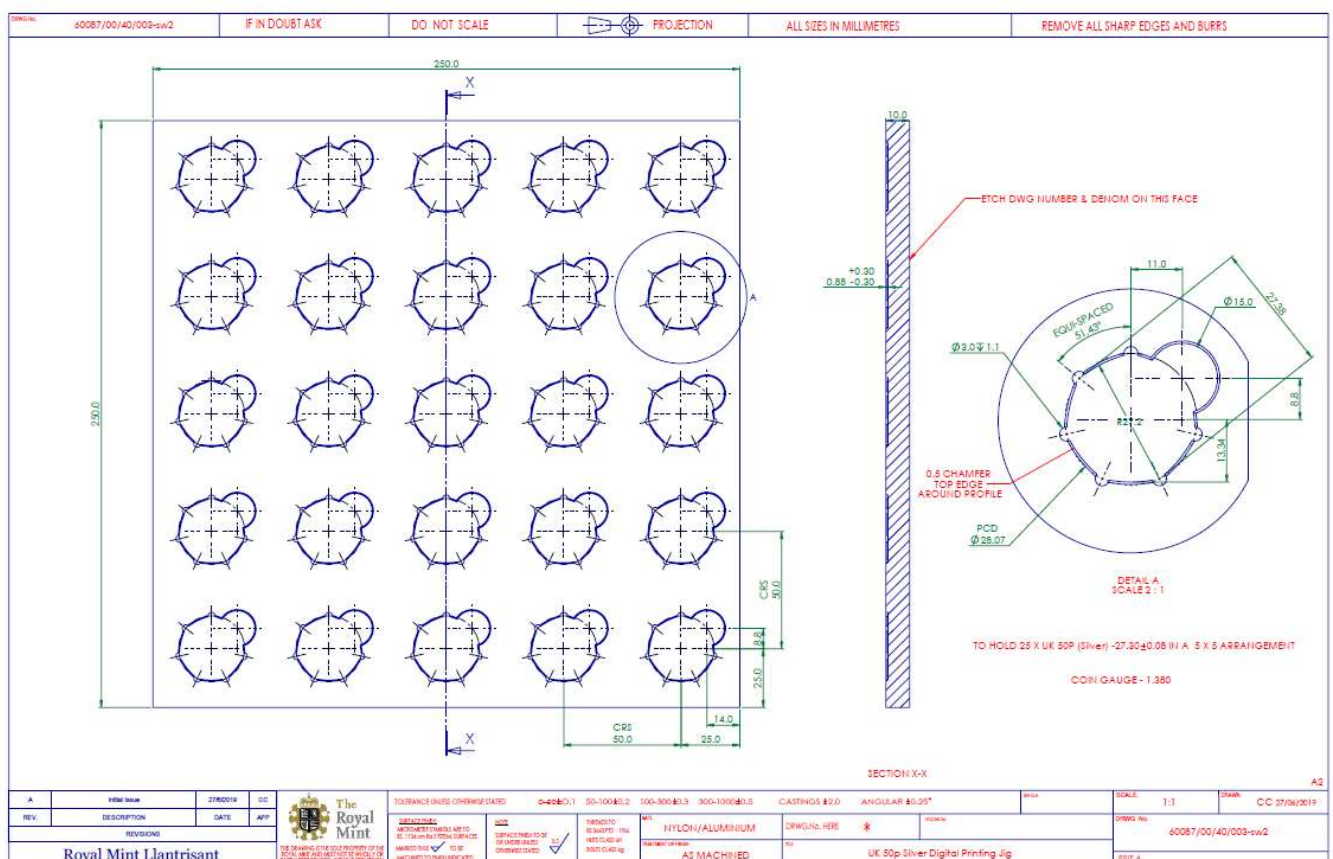
There are many printers available on the market that are capable of printing onto 3D objects but for printing on a coin there is one critical parameter. The printer must be precise and repeatable.

A thorough search for appropriate printers revealed one such printer that fit the bill, the Mimaki 7151. This printer is capable of printing a 3-micron ink dot and can then track away and print a 3 micron dot over the top with an error of +/- 1-micron.

Following a phone call with the UK Mimaki distributor several trials were arranged to develop the printing method. It was clear from the outset that the accuracy of the printer wasn't going to be the issue. What was going to be an issue was ensuring the image of the coin was consistently at the correct co-ordinates on the print table and the coin was oriented exactly for the print to lay down over the latent image.

A jig was designed to ensure the coin was placed correctly onto the print bed and oriented correctly via fixed datum edges.

Initially this was developed for shaped coin such as the UK50p since alignment could be achieved by the coins shape





The Result

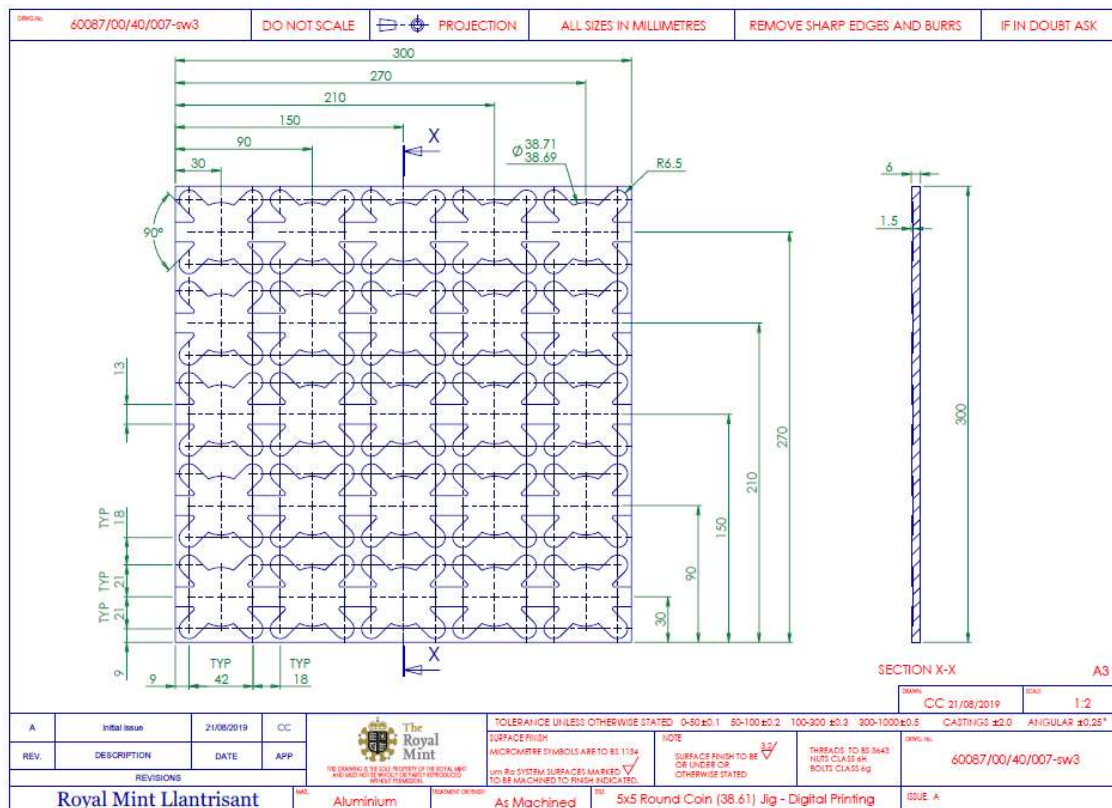
The initial coin completed using this process was the Paddington bear series. The result was a more durable higher definition image which had a more consistent colour and was repeatable.

Round Coin

Following the successful implementation of shaped coin, we needed further innovation in order to correctly orientate with no sides. The Co-ordinates weren't a problem since we could easily use another jig to control those but how do we ensure each coin is oriented exactly for the image being printed.

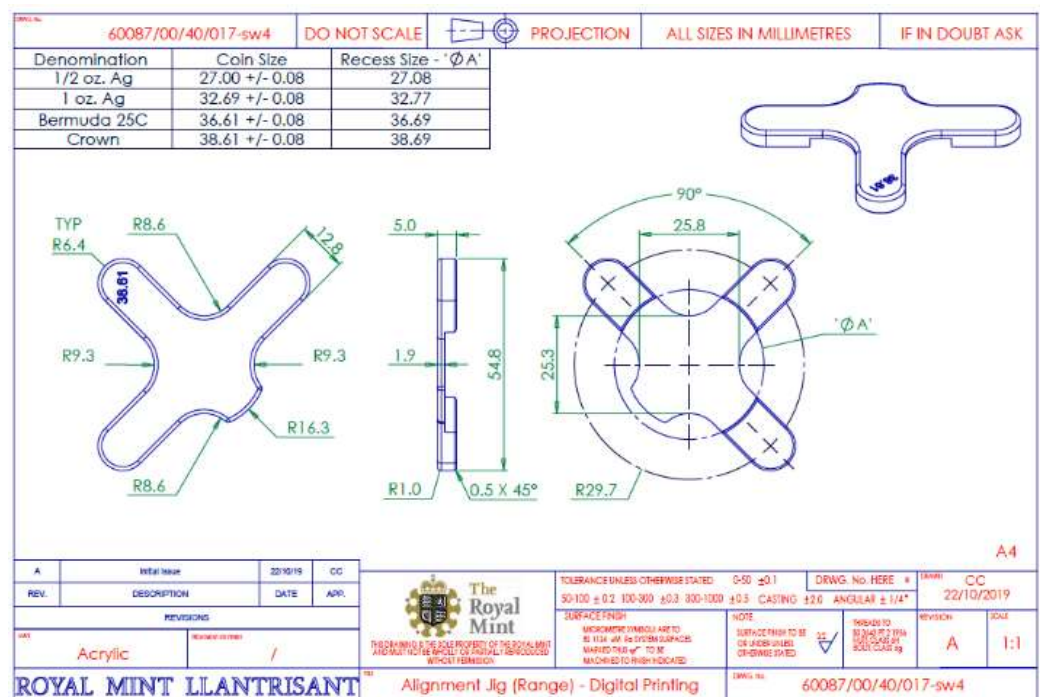


We understood that the latent image was key to the alignment and some unique feature on the latent image had to be aligned with the jig orientation in some way. We therefore needed an addition to the round coin jig that provided a datum to orientate the round coin. A round coin jig was developed that allows the placement of an alignment jig to sit over the top of the coin.



A transparent alignment jig was developed to align round coin. The three alignment arms fit exactly into the alignment jig.

Each alignment jig has the image printed on top so that his image can be aligned with the latent features on the struck coin below



The alignment jig is now produced whenever a round coloured coin is designed.

External Resources and their Management

As shown on Pearson's uncertainty map the venture was one of Development engineering. We knew what we were looking for as an output but had no idea if it was achievable or the process needed to produce a repeatable, predictable result.

The external resource employed for this project was using Mimaki's technical department in Amsterdam, their distributor in the UK & Ireland Hybrid Services Ltd, and their Sales departments Kaye Dee Printing. Time was so short that we were unable to enter a joint venture or R&D contract. To keep control from any IP we developed however we set up an NDA which was signed by all parties.

Following successful completion of the project it was suggested we considered a patent to protect the IP but the exec team felt that sharing the IP with other international mints would be a good PR campaign.

Comparison to Best Practice

When comparing this innovation to 'Innovation best practise' there is clearly a number of failings that should be pointed out.

Innovation strategy at the Royal Mint did not consider the poor capability that existed for Pad printing in line with the expected increase in coloured coin launches and sales. There was a distinct failure to identify the need for digital printing research until it was forced onto the business by unfulfilled orders. Had the idea been explored further when it was originally identified some 2 years earlier the following process should have taken place whereby the idea would be aired in the 'fuzzy front end' Ideas section of the pentathlon framework innovation funnel below.

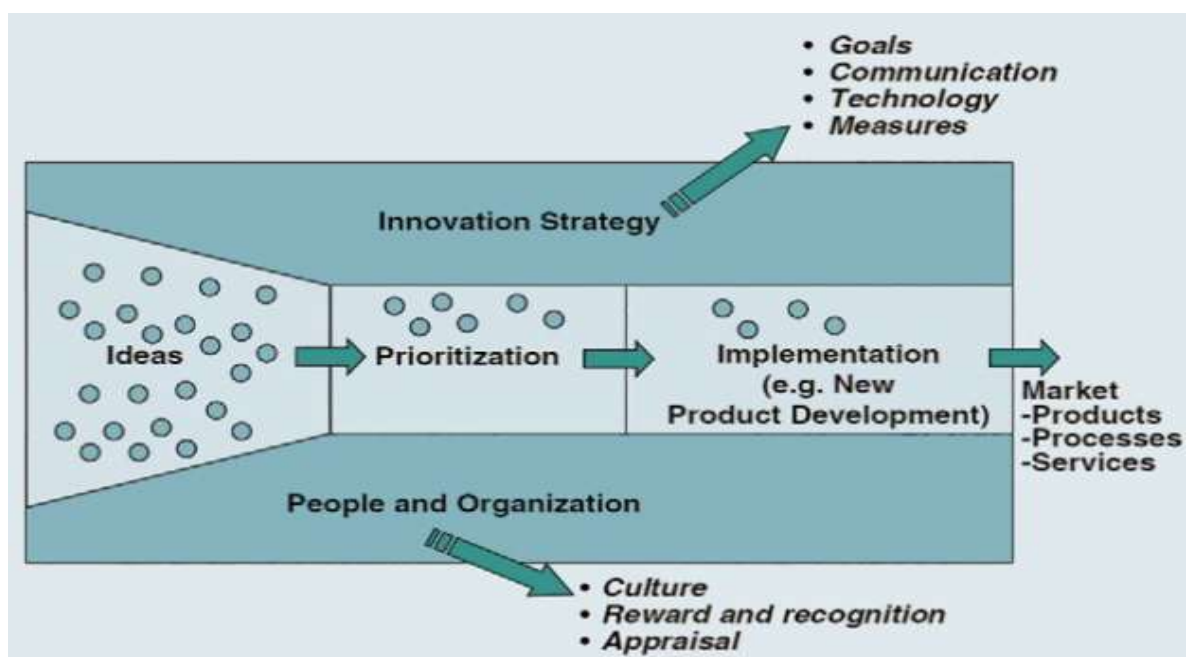


Figure 4: Pentathlon Framework Innovation Funnel (Goffin & Mitchell, 2010)

This could then move on to the Prioritisation stage having been identified as being in line with the strategy to increase launches and sales of coloured coin, before moving into implementation of the project to develop the processes for the new digital printed product.

Maintaining Management Overview

By using a Stage Gate approach a management overview could be established. Each idea would need to go through a series of gates as in the illustration below:

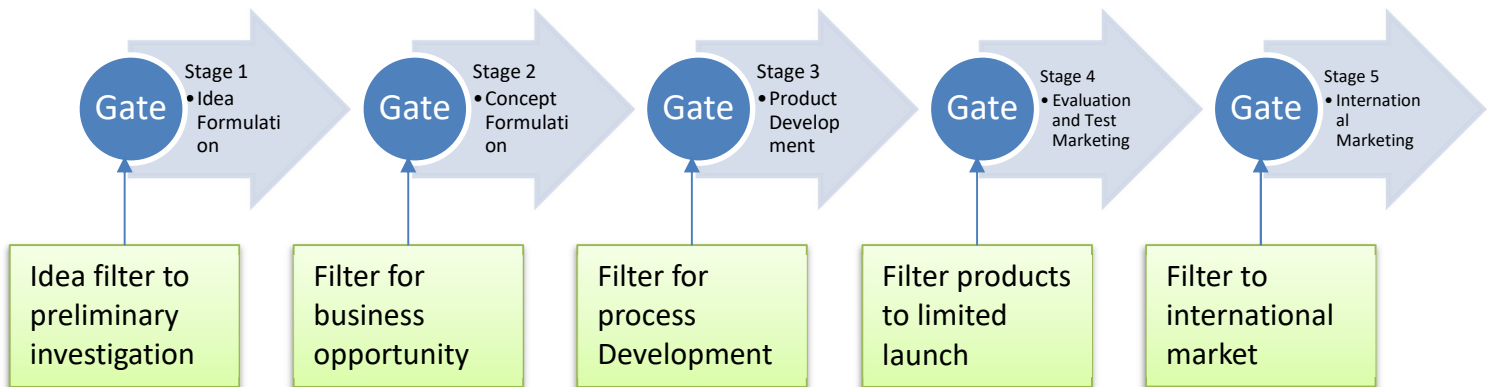


Figure 5: Stage Gate Model (Cooper, 2008)

Ideas would need to pass through a preliminary filter at stage 1 before allowed to move on to concept formulation at stage 2, this could be based on business opportunity in line with the business strategy.

Following this a decision could be made at stage 3 on the process development needed that will provide an identified new product.

A filter at stage 4 aimed at limiting a product launch to determine market reaction would give the ability to gain valuable insights knowledge on the viability of a new products success. This still gives a final opportunity to kill the project at stage 5 if a poor market reaction resulted.

The final international marketing filter provides an avenue to limit a new products availability to a national audience before committing to the international level of customers. (Cooper, 2008)

Measuring the innovation performance

As well as the classical financial measure there are also several non-financial perspectives that also add value and therefore need to be measured for evaluation. The balance scorecard as developed by David Norton and Robert Kaplan illustrates this effectively when applied to a vision and strategy. The model below illustrates this balanced scorecard approach. (Kaplan & Norton, 1996)

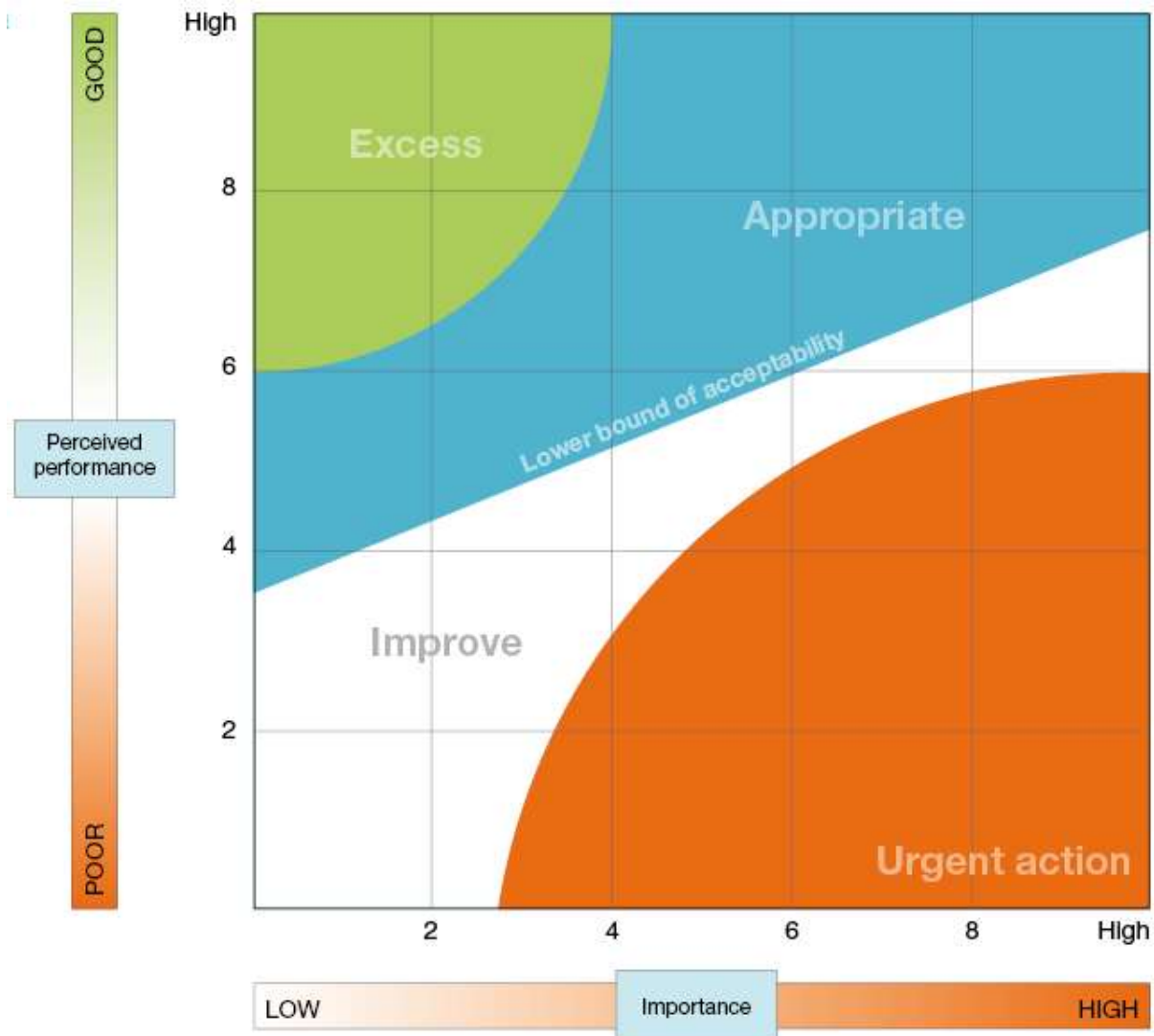


Figure 6: Balanced Scorecard Matrix (Kaplan & Norton, 1996)

Innovation Audits to identify opportunities to improve

Audits are excellent at identifying gaps in a process as well as providing feedback. A system of audit should be established that provides an objective overview of the innovation process. An independent Auditor is critical to the auditing process. Audits can typically be done internally and externally, an auditor external to the organisation however will ensure a more unbiased viewpoint is provided but an internal auditor can be utilised if an independence from the outcome can be assured.

A template for innovation Audit has been developed by Cranfield University School of Management known as FAST AUDIT. A few questions based on the Pentathlon Framework mentioned previously range from A-F on this template, when answered they will provide a plot on the following results framework that gives clear feedback on if urgent action or improvement is needed. (Cranfield University School of Management, n.d.)



- A. **Innovation strategy:** to what extent is there a clear, effective and communicated innovation strategy?
- B. **Idea generation:** to what extent is there a positive, collaborative approach to generating customer focused ideas?
- C. **Prioritisation:** to what extent are the most appropriate ideas selected for implementation?
- D. **Implementation:** to what extent are ideas quickly and successfully implemented?
- E. **People and organisation:** to what extent is there a culture of innovation?
- F. **Output:** to what extent are the number of new products and services developed sufficient?

Figure 7: Innovation Audit Result Map (Cranfield University School of Management, n.d.)

3- Critique and Evaluation of the Innovation Success

Despite the poor strategy and Innovation management at the Royal Mint the overall project was a complete success. Digital Printing has transformed the Royal Mint's method of production for coloured coin.

The final product is far superior to the previous standard with colour consistency repeatable and exact. The image is of a much higher resolution to Pad printing and the throughput has increased by over 200%.

With no manufacture of printing cliches now necessary the setup has gone from 6 weeks to 3 days ensuring that the backlog was completed and excess capacity now exists.

Standard changeover after setup has reduced from 8-16hrs to 15mins.

Previous mixing of paint is no longer necessary with ink now bought in ready for use and fitted straight on printers

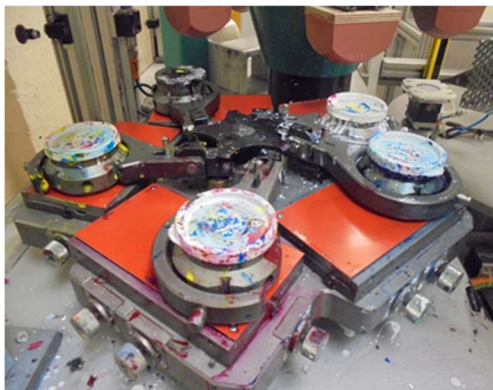


Figure 8: Pad Print manual filled ink pots



Figure 9: New Printer pre-made ink bottles

The excess capacity and knowledge gained has enabled the acrylic blocks presentation cases to now be printed in-house using the same machinery, which has alone provided an annual saving of over £600k.

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