Capitalizing on Emerging Technologies – a Path to New Opportunities Creation

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Abstract

A critical innovation competency is the ability to recognize technologies that can best be exploited by a particular company, and to drive investment in that area. We have developed a framework for identifying and developing technology-based business opportunities in new areas for a company. The framework brings together many aspects of emerging business opportunity identification and deployment, and is centered on defining a critical set of capabilities needed to address evolving market challenges. Our approach is done through a parallel understanding of market and technology trends and connecting it with the dynamics of the value chains. A new external technology that has the potential to augment your own internal capabilities can be an enabler in the "opportunity creation formula".

Keywords: technology-based opportunities, emerging technologies, emerging business opportunities

Challenges with Innovating in New-to-the-Company Space

Nearly all companies face the challenge of looking beyond incremental innovation in their existing markets to capture growth opportunities in new, rapidly evolving areas. As industries mature, profits diminish and value chains calcify, new entrants will have difficulty competing against established players for a share of market demand. In order to achieve continued growth, it becomes important to identify opportunities in entirely new spaces.

The Innovation Ventures Group (IVG) at Kennametal was formed in 2009 with the mission to identify new areas of growth for the company. In the organization, the group is positioned at the intersection of Technology and Marketing and consists of program leaders with technology and business backgrounds who lead cross-functional project teams through the identification, development, and market launch of new business platforms. IVG focuses on large platform opportunities (typically with the revenue potential in hundreds of $M) that are based on *new technology and business models*. The Innovation Ventures Group reports to a Governance Council that consists of top company executives in the all key functions. Their role is to ensure the strategic and business alignment of the programs and approve major project investments as they mature from the initial idea stage through development until the final stage of new business creation.

Delivering innovation in the new-to-company space is challenging with failure rates of 75-95% (Day 2007). A couple of the major challenges that we'd like to highlight are: identifying compelling business opportunities, and driving investment into high-uncertainty areas.

Identifying Compelling Opportunities

The first challenge is identifying opportunities that are large enough and compelling enough for executives to allocate valuable R&D and business resources. We have found that simply having a large number of ideas coming from various sources within the company - even if they were effectively captured - is not sufficient since the majority if these ideas are not "disruptive" enough. Typically, the ideas are focused on one or more product dimensions, and are essentially just new product ideas. At the same time, the ideas mentioning new and emerging technologies, often lack the market and business perspective; as a result, they are difficult for the organization to "enact".

We learned that we needed an alternative approach that would allow us to combine knowledge, perspective and insights from various functions and essentially "create" a new business opportunity. We based the formation of our business creation framework on the understanding that opportunities for new growth are often sought among 'megatrend' areas where a market place disruption is occurring. These disruptions can be caused by changes in the regulatory environment, demographic shifts or the introduction of game-changing platform technologies. By developing insights into these market "megatrends", it is possible to foresee the evolving needs that businesses will have to meet. At the same time, when considering technology-based growth opportunities, insight into emerging technology trends can be equally critical by revealing information about potential disruptions and new business opportunities.

Even though various processes have been developed for technology forecasting and scenario planning (see for example: Farrington, Henson, and Crews 2012, Manyika et al. 2013), successfully adopting technologies that can serve as a foundation for new business *outside of the company's core* remains challenging. Other approaches that focus on analyzing evolving value chains driven by the "megatrends" (Mills and Siempelkamp 2012) rely on internal technology capabilities and do not address the aspect of integrating external technologies. Therefore, we have established our own formula for identifying and developing successful opportunities in new spaces. Our approach is based on the view that we have essentially the same access to market and technology information as the competition. The ability to successfully deploy a new business thus depends on our ability to 1) generate insights based on market and technology trends, 2) identify opportunities that align with our company's organizational structure and internal capabilities, and 3) deliver value within the context of the relevant value chain dynamics.

Driving Investment into "New"

Another major challenge we faced was driving investment decisions. As with most companies, Kennametal's executives must manage two types of investment: those to defend the core and those in new opportunity growth. New opportunity growth usually entails greater levels of uncertainty, creating more reticence to invest. One of the important things we learned in order to be successful in driving investment in a potentially disruptive technology, was 1) putting the

technology in the context of a business opportunity, and 2) providing a framework for making investment decisions that would communicate both the upside and potential economic risks in a somewhat quantitative way.

In this paper, we share ours insights developed from experience in managing a large number of opportunities through various development stages. This knowledge gained was developed based on opportunities that span across various technology and engineering domains, as well as a variety of markets. Figure 1 shows the portfolio of programs our group has worked on across a range of market and technology uncertainties.

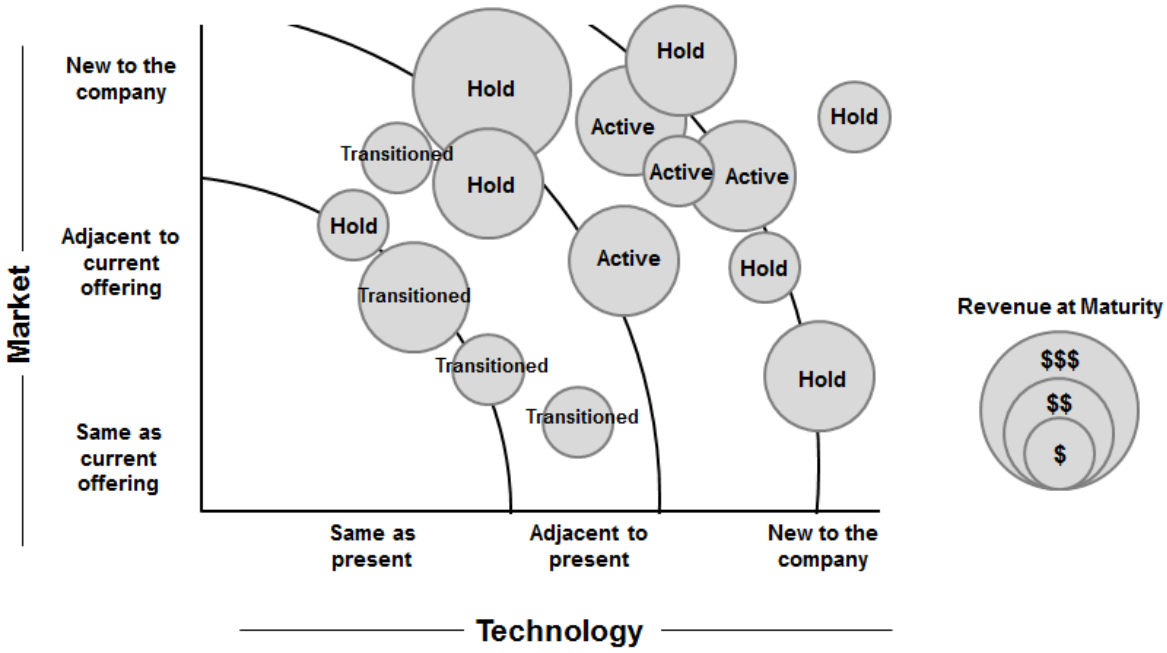


Figure 1: The Innovation Ventures Group at Kennametal has existed since 2009 with the goal to deliver technology-based opportunities that are in the new-to-company space. This figure depicts the quantity and relative size of the programs that have been worked on. This method of portraying the portfolio was adopted from George Day (2007).

This paper outlines the process we use to identify opportunities in new spaces and provides key understandings that we have developed by applying it. We have also adopted various (some developed by Kennametal and some previously discussed in literature) tools and brought them together in one framework that we found to be effective in managing programs with high inherent uncertainty. See Figure 2.

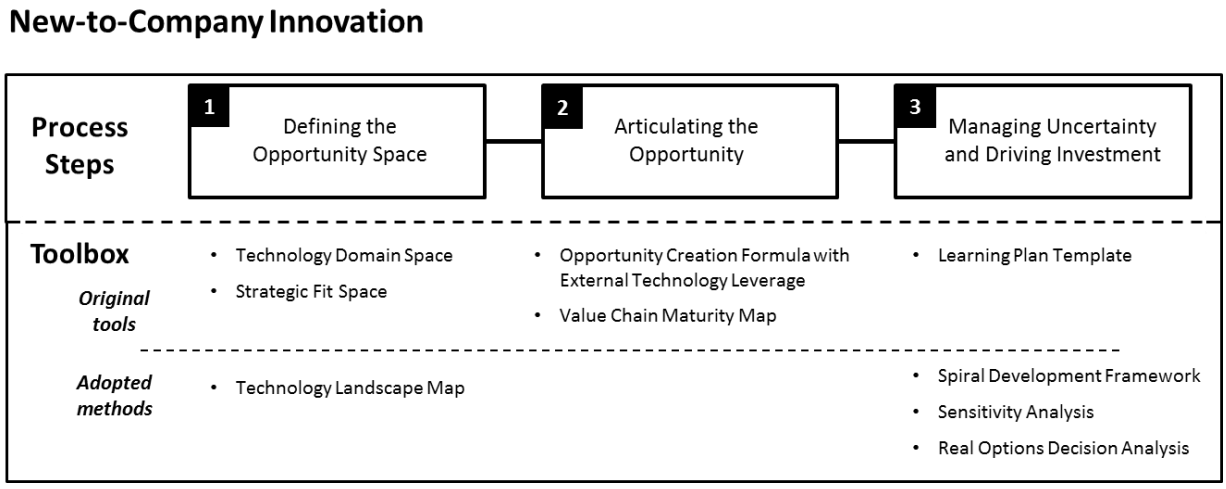


Figure 2: To overcome some of the challenges associated with delivering new-to-the-company innovation opportunities, we follow three major process steps shown in the figure. Each of these steps uses various tools that we developed or adopted to improve the results in each of those process steps.

Central to our approach is:

1) Defining the opportunity space in the context of unsolved challenges in relevant megatrend areas while strategically and proactively identifying emerging technologies that are complementary to existing internal capabilities

2) Articulating the opportunity based on a systematic analysis of our position in the evolving value chain

3) Deploying a spiral discovery process and using financial modeling tools to communicate economic risk in order to drive investment in high-uncertainty programs.

1. Defining the Opportunity Space

For articulating a new business opportunity in the white space we have found it helpful to adopt a central principle of effective corporate strategy that clearly answers these two questions: 1) Where to play and 2) How to win. The "where to play" element can be considered the target market segment or customer application, and for "how to win", it's the set of capabilities that you will deploy (Lafley and Martin 2013).

Marketplace disruptions, which often result in business opportunities, happen at the intersection of market needs and technology options. For example, in the case of Apple's iPod it was the needs to portable, easy-to-access music paired with the emergence of lower cost digital storage technologies. Therefore, in IVG at Kennametal we have adopted a strategic approach for

identifying new opportunity spaces based on placing equal importance on developing an understanding in both market and technology areas relevant to our company. We have found that building organization awareness in both these areas makes cross-functional ideation of new growth opportunities more effective.

The process itself for identifying new business opportunities can be either "market back" or "technology forward". In both cases, we believe success depends on the ability to generate new value for the customer with specific capabilities rooted in core competencies that can be augmented with complementary external technologies through open innovation. See Figure 3.

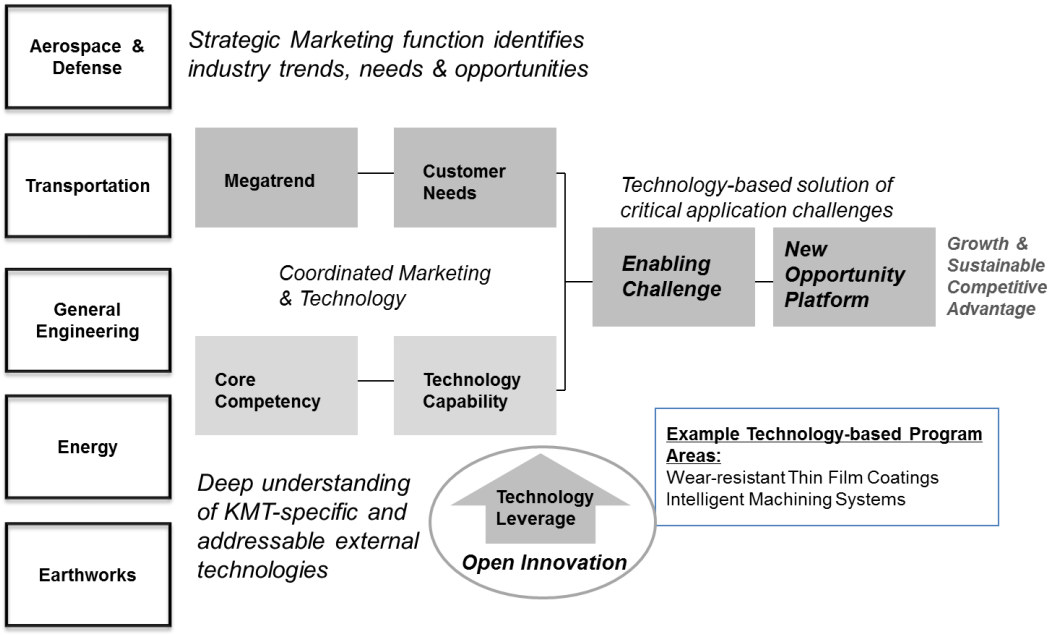


Figure 3: The best opportunities exist at the confluence of unmet customer needs and technologies that leverage existing capabilities. The process of defining an opportunity can begin with the top path (Market) or the bottom path (Technology). The left side of the figure shows the vertical industries that Kennametal targets.

Market-Back Approach

One example of a "market back" opportunity space rooted in a megatrend area that Kennametal explored is electro-mobility, where rising energy costs and increasing fuel efficiency standards have led to the growth of electric and hybrid-electric vehicles.

The key in defining our opportunity space in this vast market was to focus on unsolved problems that align well with our technology competencies. Through secondary market research and using specific performance objectives for battery quality (e.g. energy density) provided by the US Department of Energy (US Department of Energy 2014) we identified the application challenges in the powder-metal-based electrodes of energy storage devices. Powder metals are used to form the electrodes and contribute significantly to the overall performance of the battery and

subsequently the vehicle. The powder-metal area is also one area where Kennametal has strong internal technical competency, and therefore aligns well with our internal capabilities.

Detailing the technology requirements during the early opportunity evaluation stage allowed us to understand how our internal capabilities could be complemented with specific external technologies to combine and produce a compelling offering. To accomplish this external technology identification and selection, we used a systematic Technology Landscape Mapping (TLM) process (Spitsberg et al. 2013). In this case, the TLM process identified a promising porous material with 3x improvement in a critical performance dimension and which aligned well with our technical competencies.

The powder-materials-based electrode solution for batteries is one example of how Kennametal can define an opportunity by tracing back from a megatrend area like electro-mobility. In this example we saw that emerging technologies can be a critical element for "how to win" and position our company to access opportunities that otherwise would not be possible.

As mentioned earlier and depicted in Figure 1, you can also begin to define an opportunity space by actually starting with promising emerging technologies; i.e. moving from "how to win" to "where to play".

Technology-Forward Approach

The "technology forward" opportunity approach can be as equally effective as the market-back if identifying emerging technologies that have new business potential is done through a strategic process rather than relying on opportunistic occurrence.

While information on emerging technologies is relatively accessible (Kumara 2014, Shukla 2014), one big challenge that we found is the question: *what does a particular technology mean to our company.* To develop a rationale for "zooming in" on a few critical technologies that can make a difference for our business, we implemented a two-step approach:

(i) The first step involves defining the company's technology space in a manner that creates a framework for relating seemingly "distant" emerging technologies to our core competencies;

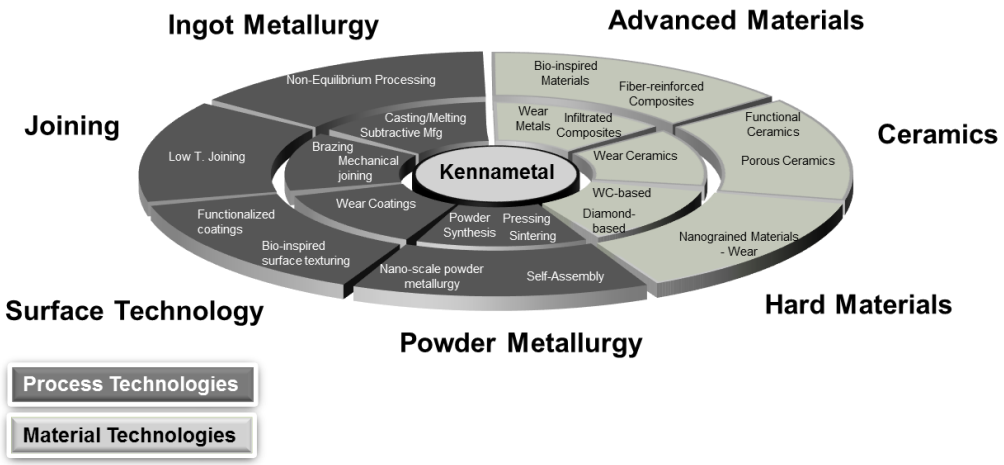
(ii) The second step focuses on identifying strategic emerging technologies by mapping the identified technologies on to what we call a "Strategic fit" space. This forms the important input in defining the opportunity space and then to articulating business opportunity.

(i) The Technology Space of a Company

The technology space of a company comprises all the technologies it uses to create its products and to provide them to their customers. It can be defined in such a way to capture technology capabilities that are present currently and those that are under development. We use a broader

definition of the space that allows us to capture our current capabilities along with those that are related and can be exploited by us to enter into new markets (see text box 1). This broader definition of the domain includes core technologies as well as those that Kennametal can potentially leverage because of commonality/overlap in manufacturing process or technical expertise.

Text box 1



A representation of the Technology Space for Kennametal's materials science related domains.

This is an example of the expanded technology space for Kennametal in terms of its material-science-related domains. The entire space is represented by seven domains. Within each segment, the inner ring includes technology areas that we have in-depth expertise in, and constitutes our core. The outer ring includes technology areas that are outside of our core but *share some critical characteristics and attributes with the ones in our core* (such as commonality/overlap in manufacturing processes or technical expertise). It is our expectation that because of these commonalities, Kennametal has the potential to exploit those technology areas with reasonable success. For illustration purposes we have included few examples of our technology areas inside and outside our core in various domains.

If the "inner ring" were the only technology areas we were considering exploring for new opportunities, our options would likely be limited. However, with the expanded definition, a potential fit with an opportunity is much more likely.

For example, consider the ceramics technology domain: If we consider only our core technologies, we would be focused solely on new opportunities in wear applications. However, with the expanded domain, we can consider other opportunities that are addressed by related

technology areas such a porous or functional ceramics. These different but related ceramics technology areas are interesting because they are a good fit for many Cleantech applications that cannot be addressed with our core wear-resistant ceramic materials.

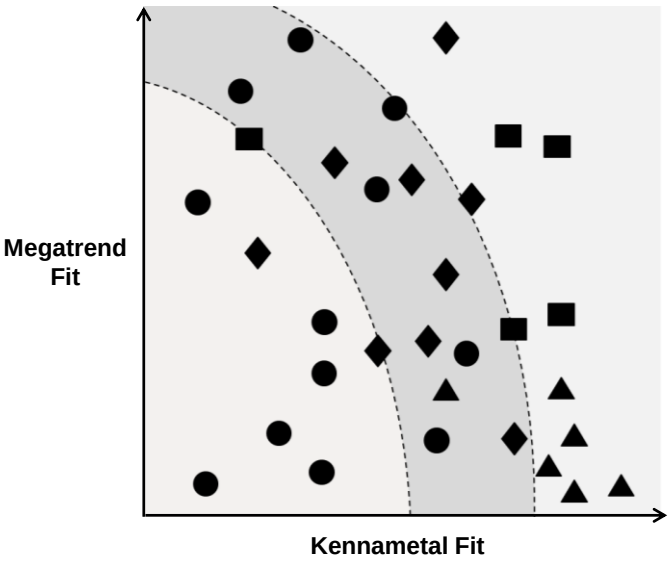
In summary, we found that the definition of your own space plays a critical role in the success of identifying emerging technologies that may have high potential for innovation in our company. If we only consider technology areas within a narrow definition of our domain space, we may miss new business opportunity(s). Likewise, if we just target technologies solely based on their market attractiveness, they may not be aligned with our core capabilities and we may not be able to convert them into a successful commercial offering.

(ii) Identifying strategic emerging technologies

Once we have defined our technology space, the next step is to identify emerging areas within each domain and then select promising technologies. To accomplish this, we start from engaging a team of external and internal experts and, using a crowdsourcing approach, asking them to identify trending areas. This process usually results in a substantial list of candidate emerging technology areas that can potentially be relevant to our business. It however does not provide enough detail to make the selection.

Since it is not practical to investigate all suggested areas with the same rigor; we sort trending technologies along two dimensions: 1) alignment with current megatrends and 2) fit with the company. Each of these dimensions includes several weighted factors. The output of this prioritization assessment is plotted onto a "Strategic Fit" map (text box 2). The Strategic Map makes visualization of how the identified technologies fit along the two dimensions easy and the rationale for selecting the most promising technology areas clear.

Text box 2: Strategic Fit Map



Megatrend Fit score based on the opportunity size of the technology and impact it will have in the application space related to:

- Cleantech
- Emerging Market Growth
- Demographics
- Digitization

Kennametal Fit based on alignment with our existing mission and ability to exploit our technology.

This is an example of a Strategic Fit Map generated for four of Kennametal's materials science domains, where the internal team identified more than thirty trending technology areas. Each shape (circle, square, triangle, and diamond) represents a technology area belonging to one of the four domains. Please note that each technology area on the Strategic Fit map encompasses several specific technologies. We show three zones on our Strategic Fit map: The outer zone includes those technology areas that may be of the most importance to the company. The technologies in the upper right corner are those that present best fit with both megatrends and internal company capabilities and therefore should be explored for the potential business opportunities. Using the earlier example of energy storage devices, powder metal technologies that are used to form the electrodes could be discovered through this approach and would be placed in this zone with a recommendation for further exploration. The technologies in the bottom right corner may present opportunities or disruption for the core business, and even though may not be a particular fit with megatrends, can be very important for the business. The second (middle) zone includes technology that show only moderate fit with the trends and/or Kennametal and can be addressed with a lesser priority. The inner zone has technology areas with least fit on both scales and warrants monitoring only for peripheral awareness.

Once the promising technology areas are identified, the next step is to conduct an in-depth assessment to understand the explicit market needs being addressed, and the specific technology(s) that are best suited to meet those needs. The process we use for the in-depth investigation is Technology Landscape Mapping (Figure 4) (Spitsberg et al. 2013). The outcome

of this process is the identification of specific technologies that have the highest potential of addressing the market needs/drivers and allows you to hone in and define tangible opportunities.

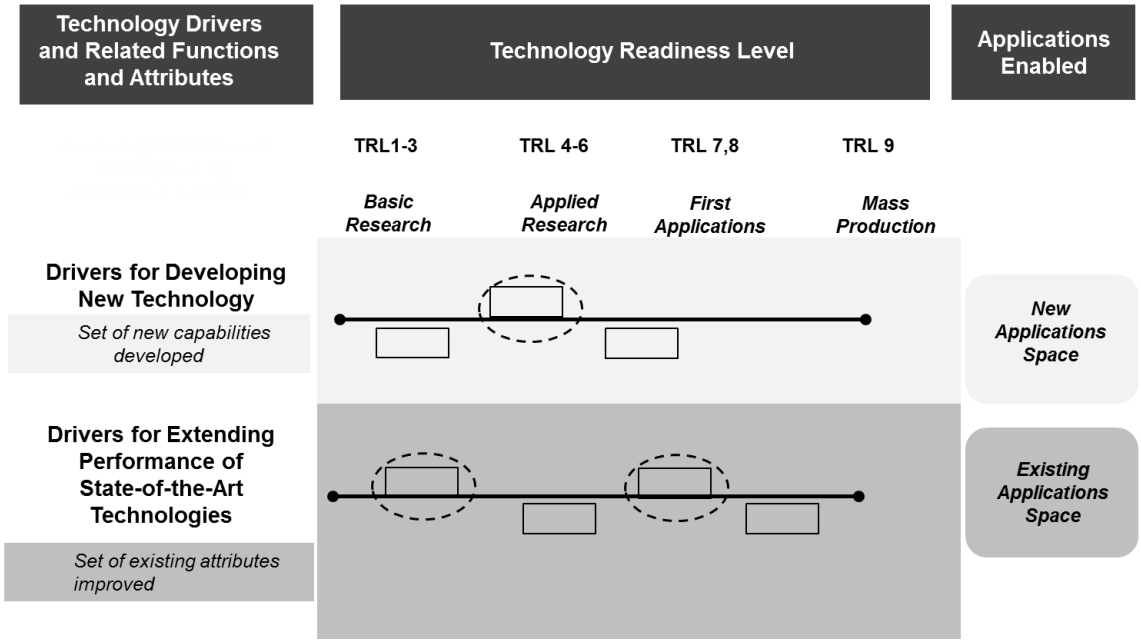


Figure 4: The Technology Landscape Map systematically identifies and compares specific emerging technologies, their main attributes (left side) and the technology readiness level (center) in the context of the application areas targeted/enabled by these technologies (right). (refer: Spitsberg et al. 2013)

Once specific technologies and application areas are identified using the above approach, the opportunity space starts to become clear.

2. Articulating the Business Case

The Opportunity Creation "Formula"

The next step involves bringing the various "pieces of the puzzle" together to articulate the business opportunity. As we stated earlier, a well-defined growth opportunity will articulate "where to play" (the specific user segment and application) and "how to win" (the set of capabilities needed to deliver value). But even with a clear understanding of the opportunity, it is critical to consider whether there is a reasonable chance of commercial success.

We have screened a large number of new growth opportunities leveraging our current competencies in advanced materials and processes. We have seen that the 'how to win' element

of a winning strategy must consist of more than the technology-related capabilities, but the business-related capabilities as well. The winning formula consists of

Technical Capabilities (TC) + Business Competencies (BC) = New Business Opportunity

Both Technical Capabilities & Business Competencies can be broken down into sub-factors. Elements of Technical Capabilities include: material, process, part design, and application knowledge. Typically, a differentiated technology capability occurs when you can combine 2 or more of these critical elements. In the case of product development in the core, a company will mostly contain a critical mass of these capabilities internally. However, when considering entering new spaces, there often does not exist enough critical mass of the TC factors internally, and external technologies are needed to augment existing core strengths and achieve a critical mass of technology capability. The formula can be modified to illustrate the importance of external technology leverage (ETL):

[Internal Technology Capabilities + ETL] + BC = New Business Opportunity

The Business Competencies are just as critical for success as the technology factors. The important business elements include channel access, brand equity, strategic alignment, business and manufacturing infrastructure.

For an established organization like Kennametal, we have found that the formula for success for new opportunity creation combines a critical mass from both these buckets -- technical and business. This explains why you cannot evaluate the potential of a promising emerging technology without considering it within the context of the other important technical and business attributes that a company possesses.

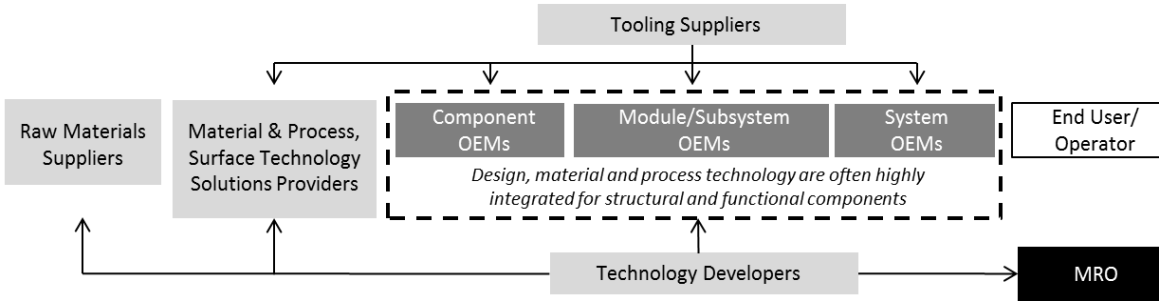
Considering Value Chain Dynamics

The final consideration when analyzing a new opportunity is to understand the dynamics within the value chain. When we have a potential solution in mind, it's important to see how the solution maps onto the existing or evolving value chain.

One important observation we made is that technology components are often highly integrated at the system level leaving limited space for new entrants. Developing an understanding of these limitations early in the process saved valuable time and resources from going down a development path or adopting a technology that would be impossible to turn into a business opportunity. An illustration of this point is given in the context of our earlier example about the energy storage opportunity for hybrid and electric vehicles (text box 3). Alternatively, when possible, this understanding of the value chain dynamics can help more effectively guide the development program toward defining partnerships that are essential for commercial success.

Text box 3

Below is an illustration of a typical value chain



Here is an illustration of a typical value chain for industrial manufacturing applications such as aerospace assemblies or automotive systems. Many value chains exhibit high levels of integration in system design and production making it difficult for new technology developers to penetrate a market at the component or subsystem level.

Returning to our earlier example about the energy storage opportunity for hybrid and electric vehicles, we saw that there is a well-defined challenge in this application for improving the energy density of the devices which impacts the vehicle range. When viewing this opportunity through the new opportunity formula: TC + BC = NBO, we had enough pieces between our existing powder metallurgy technical competency, brand equity as a powder metal solution provider and existing processing infrastructure, to form a reasonable new business opportunity hypothesis. Through our technology mapping process (Section 2), we were able to identify a promising electrode material that addressed the energy density challenge in a significant way. By matching that external material technology with our internal processing capability, we had the pieces to address the specific problem. When we examined the value chain for the energy storage device market, we observed that the electrode subsystem and the battery system production were most often integrated into the same process, making it unlikely we could enter the market with only subsystem solution. Therefore, it was clear that our best commercialization path with our promising electrode material solution was with a proprietary powder product to supply the system makers.

One other important insight here is that the chances for a technology-based business opportunity are largely dependent on the maturity of the value chain. We have observed there is an apparent correlation between maturity of the value chain and the type of partnerships that are forming.

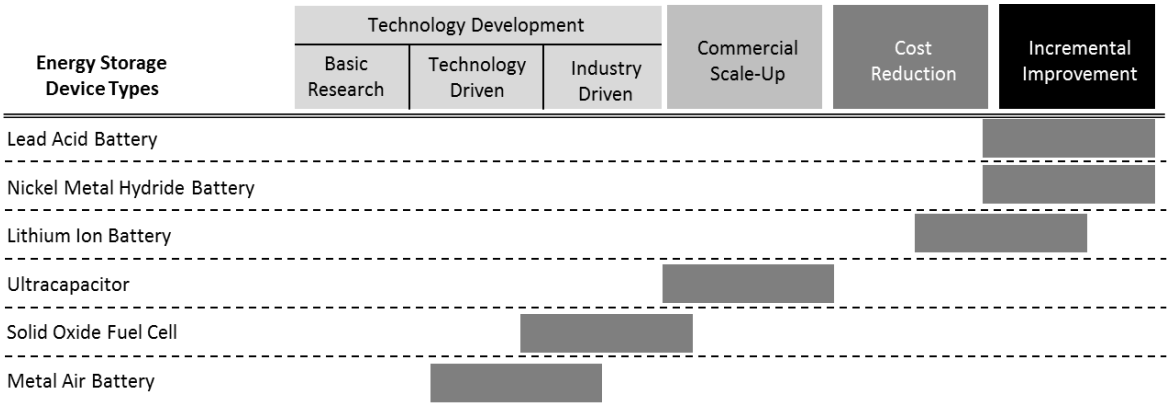


Figure 5: Depiction of different stages of value chain maturity showing relative maturity for different energy storage technologies. We have found that there is a greater likelihood to penetrate new market segments with promising emerging technologies in value chains in the late Technology Development stage.

By looking at various opportunities (for illustration purpose, we continue to use an energy storage related example in Figure 5), we have developed this insight: markets and opportunities in the scale-up phase or later generally show high levels of component and system integration and the supply chain networks are already established. The types of opportunities in these stages generally tend to be high-volume suppliers competing on cost. On the other hand, markets and applications in the early stages of Technology Development possess high levels of uncertainty and selecting emerging technologies contains significant risk. As a result we found the best chances for technology-based business opportunity lie in value chains in the late Technology Development phase where the potential for creating value from integrating a few technology capabilities to enable commercial scale up is high.

3. Managing Uncertainty and Driving Investment

As we mentioned earlier, one of our main challenges in developing opportunities in areas with high technology and business uncertainty is securing program investment. We found it is critical to provide a framework that would allow key decision makers to prioritize these investments within the overall opportunity portfolio the company was pursuing. To do that, we again adopted one of the main principles of corporate strategy, which is not to eliminate risk but to increase the odds of success (Martin 2014).

In our experience, it is critical to 1) focus on understanding sources of uncertainty, and relating the program's progress to the reduction of key risk drivers; 2) quantitatively describe the risk

drivers and to provide an analytical investment decision framework, and 3) provide the ability to stage the investment decision.

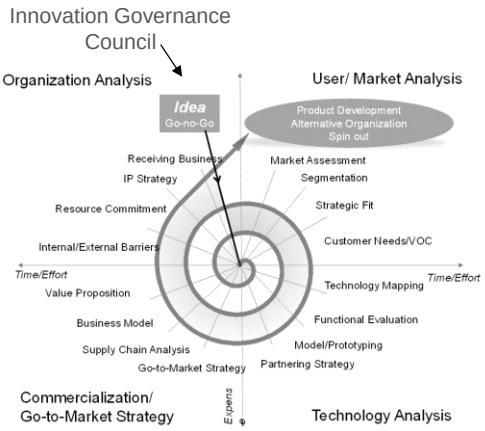
Focus on Uncertainty Reduction and a Learning Plan Approach

To create focus on reducing uncertainty, we have adopted the spiral development model proposed by Deloitte (Gallagher, George, and Kadakia 2006), where the process follows an iterative path of interdependent technology and business development (outline of this approach and the details of the Learning Plan tool developed by Kennametal are shown See *text box* 4). As opposed to a linear stage-gate process (Cooper 1990) used to manage programs in the "core" (where execution is focused against well-defined objectives and standardized deliverables are used to minimize process variability) this approach focuses on defining and addressing key uncertainties and allows for a change of course based on market feedback.

Text box 4

Organization Analysis

Dimension	Description	Status
Receiving Business – Transition Plan	Includes market development, manufacturing capability demonstration, sales force training, etc	
IP Strategy	Consideration of intellectual property options and issues including patentability and/or trade secrets.	
Resource Commitment	Description of resource requirements and the ability to leverage across the organization to develop and commercialize proposed solution.	
Internal / External Barriers	Identification of internal and external commercialization risks.	



User Market Analysis

Dimension		Description	Status
Market Assessment	Market Size	The total size of the opportunity space	
	Growth Rate	Estimation of the rate of growth of the industry	
	Industry Landscape	Identification of customers, competitors, complementors, etc	
Segmentation		Dividing the market into distinct groups with distinct needs in order to target an addressable market space	
Strategic Fit		Expression of the degree to which KMT is matching our resources and capabilities with the opportunity and can be developed into a competitive advantage	
Customer Needs / VOC		Understanding of the functional requirements in the market needed to meet customer needs.	

Commercialization/ Go-to Market Strategy

Dimension	Description	Status
Value Proposition	Statement that expresses why a customer would want to buy the product or service from Kennametal includes definition of the job-to-be-done.	
Business Model	Define how Kennametal would make money. Provide example list of our potential customers and show how KMT will price offering to generate a profitable return	
Supply Chain	Identification of manufacturing and supply route in order to produce the proposed solution.	
Go-to-Market	The plan that describes how KMT will bring the hypothesized solution to the customer.	

Technology Analysis

Dimension	Description	Status
Technology Mapping	Identify technology attributes that correlate with customer defined needs. Define potential technology solutions that can potential fulfill customer requirements	
Functional Evaluation	Conduct initial screening tests of potential technology solutions to determine feasibility	
Model / Prototyping	Build prototype models a conduct testing directly in application environment or simulated test set-up	
Partnering Strategy	Identification and engagement of potential external technology partners that own critical technology components that could be integrated into the final solution	

Innovation opportunities begin with a description of the compelling unmet needs and follow a spiral path of interconnected & interdependent Technology & Business Development. Use a Learning Plan approach in the four areas of User/Market, Technology, and Commercialization Go-to-Market to identify and reduce development uncertainties quickly. (Spiral model adopted from Gallagher, George and Kadakia 2006).

During each stage, which represents one revolution along the spiral, Learning Plans are formulated for the development activities to address the largest uncertainties in each of the four main areas. The Learning Plans are then re-formulated at each stage with overall uncertainty getting reduced with each "revolution along the spiral".

Specific learning plans are detailed below:

Text box 4 (contd.)

Organization Analysis

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Text box 4 (contd.)

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Text box 4 (contd.)

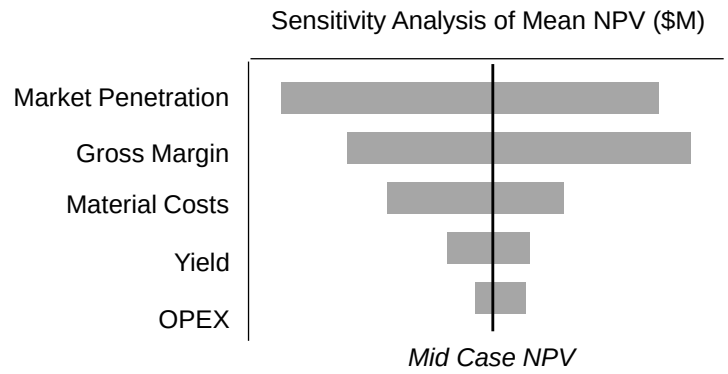
Technology Analysis

Dimension	Description	Status
Technology Mapping	Identify technology attributes that correlate with customer defined needs. Define potential technology solutions that can potential fulfill customer requirements	
Functional Evaluation	Conduct initial screening tests of potential technology solutions to determine feasibility	
Model / Prototyping	Build prototype models a conduct testing directly in application environment or simulated test set-up	
Partnering Strategy	Identification and engagement of potential external technology partners that own critical technology components that could be integrated into the final solution	

Future Profit and Loss Modeling

To help provide a quantitative view of the program value when it is not yet possible to develop a solid business case we have adopted a "Future P&L" Modeling approach. This approach quantifies the key risk drivers and models total variability in the expected Net Present Value (NPV) at each stage of the program using Monte-Carlo simulations or similar methods. An example output of such modeling is shown in text box 5.

Text box 5:



An example of the output of a sensitivity analysis for a mean 10-year NPV. The bars show the effect the main inputs into the future cash flows from the economic model (on the left) on the projected mean 10-year NPV (Mid Case NPV). The size of the bar represents the magnitude of the effect of the particular input, when it is varied within its assumed range of uncertainty. The larger the bar, the higher the risk associated with this variable. This should drive the focus of the program activities on the areas of the largest risk areas. The key assumptions in the model (such as the market size, penetration rate, manufacturing cost and sales price, as well as capital expenditure and operational expenses) are directly tied to the uncertainties identified in the Learning Plans, and the output shows the sensitivity of the variables on the program NPV.

We make it clear that these forecasts are only valid *based on what we know at the time* and that they will be further refined and adjusted based on new information gathered. We found that this approach drives focus on the relationship between program activities and business case inputs, thus making the required investments more relevant. This structure helps us communicate the program risks in a quantitative way and effectively relates them more meaningfully to the probability of commercial success.

Investment Decision Supporting Framework

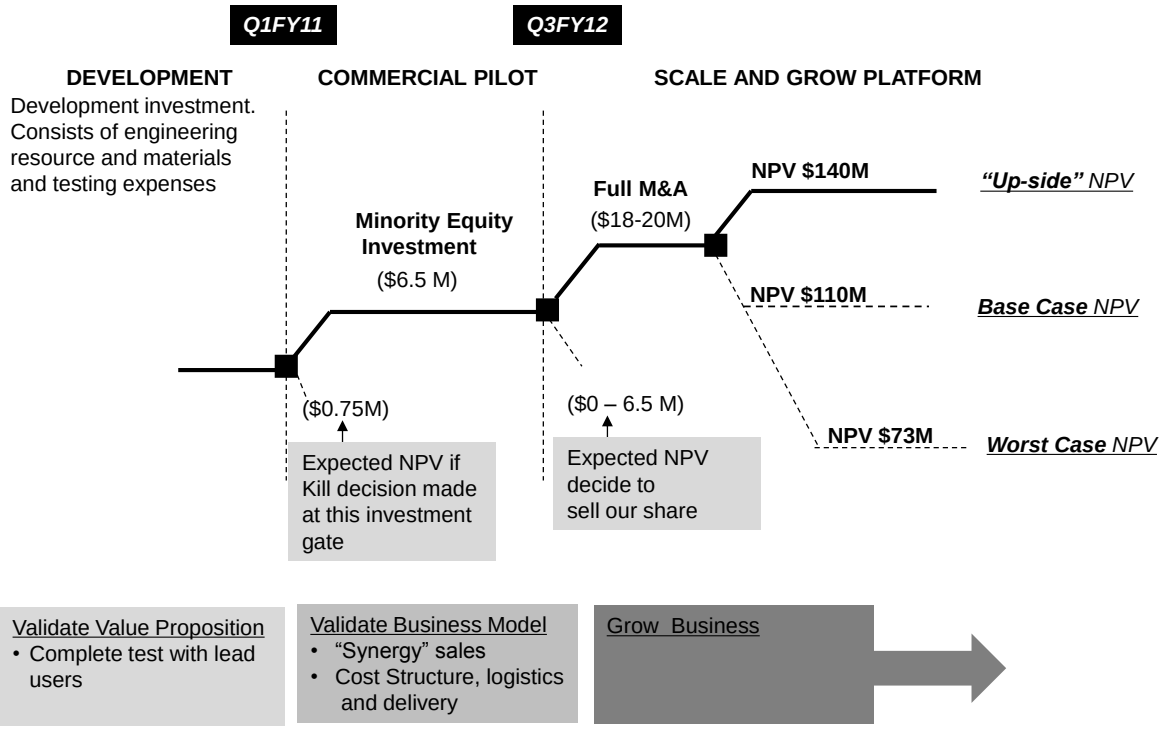
The idea of "asymmetric risk" – where upside is much greater than downside – is another concept that is useful when making investment recommendations. When asymmetric risk is considered in parallel with optionality, providing the ability to stage investment decisions, it significantly reduces organizational barriers for approving high-uncertainty investments. To implement this concept, we have adopted a Real Options framework. This approach is based on the perspective that an investment in a new technology or new business opportunity is not a single-stage decision, but rather a sequential investment in "real options" (Bowman and Hurry

1993, Mitchel and Hamilton 1988, Sanchez 1993, Dixit and Pindyck 1994). We recognized that this approach was a good fit for managing programs with high levels of uncertainty in our company.

During the early stages, an initial investment is typically required to enable the opportunity to be further explored, thus creating a real option. As the development program unfolds, additional investments can be made in the original concept, or new knowledge may lead to alternative opportunities. The choices at each decision point can be presented as a three-dimensional decision tree that depicts the investment required for the next stage, the potential the investment can lead to, and the loss that will occur should the program stop after the next stage. A schematic example of a decision tree for one of our programs is given in text box *6.*

We have found that this real options approach provides structure in making decisions and helps frame the uncertainty and investments risk in a more constructive way – as something that can be positively exploited rather than be avoided.

Text box 6:



An example of the investment "decision tree" based on the real option concept. It depicts various "real options" at different stages of the program, including the staged investments that position it toward the future opportunity. The other choices are to stop and redeploy assets, or to reapply the developed knowledge to a different market target. At the final development stage shown, it includes three scenarios associated with the option to capitalize the commercial pilot – the conservative case, the upside, and the worst case scenario. The conservative case would typically be tied with the "lead pin" customer segment. It would have a better defined business case making the investment into the original manufacturing pilot less risky. Even though the returns associated with this case are usually on the "conservative" side, the value of the program also includes the option of make further investments into a larger business with the higher overall returns.

The Impact

The Innovation Ventures Group at Kennametal, although relatively young, has successfully transitioned several programs from conceptualization to commercialization in areas as diverse as digital intelligence, advanced materials and emerging manufacturing technologies. These new-to-the-company programs are 20-100 times greater in terms of revenue potential compared to a typical new product development project in the core. And, the total value of IVG's current

pipeline is about one third of the total R&D pipeline in the core. This success is due in large part to the approach outlined in this paper for resolving critical innovation challenges like opportunity identification and aligning organizational support.

The approach we shared for opportunity creation relies on the integration of emerging technology with a company's inherent capabilities. We believe this merger of emerging external technology and internal competencies to address critical market needs leads to successful differentiated opportunities. The process of opportunity discovery does not require starting with the market needs. It can begin with the technology as well. What's important is to use a systematic and parallel understanding of market and technology trends connected to an analysis of the dynamics in the value chain to pinpoint areas that can be addressed by the specific capabilities of your company or those capabilities augmented by strategic technology partner relationships.

Securing internal investment in promising technologies requires that the technology is articulated as a business opportunity and includes a decision-making framework that shifts the focus from risk to opportunity. An oversight structure with senior leadership that provides expertise and decision making authority to support these high-uncertainty, longer-term investments is also critical.

Innovating outside the core is a challenging proposition. Established companies can take advantage of their knowledge depth and technology infrastructure to penetrate evolving market areas and compete successfully against more agile start-up companies. We found that success requires a broad set of technology and business skills from dedicated cross-functional teams employing the right set of tools. We believe that the application of our approach will help other innovation professionals looking for innovation outside the core to improve their odds of success and create the structure for other companies considering new- and adjacent-space initiatives to get started.

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