Developing an Industry Roadmap Model using Future Thinking and Business Model Integration

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This paper reports on an industry roadmap model that was designed to construct a conjunctural roadmap for the aluminium industry in South Africa. This conjuncture addresses both social and economic imperatives for the industry, the society, individual companies and the country at large. The roadmap model is based on an integrated business model approach and addresses a wide spectrum of roadmap units of analysis including market, product and technology, knowledge required, complements in industry, dynamic capabilities, platforms and business ecosystems. The roadmap model is guided by a future vision for the industry. This vision was determined in a structured future thinking process, including doing mind-time travel between the past, the present and the future; high level mapping of the future; identifying emergent technologies, human behaviour and events; deciding on their relevance; considering their higher order impacts; imagining the future for the industry; deepening the future, using causal layered analysis; developing scenarios, and selecting the preferred scenario; and formulating an ambitious vision. The industry roadmap model was then combined with the vision in an industry roadmap canvas that was used in brainstorming and critical discussion. The outcomes of expert opinion were combined and translated into an industry roadmap. This led to the identification of interventions that will bring about industry goals and achievements. The conjunctural aspects addressed include profit for enterprises that will generate employment; industry growth that will result in market leadership; human well-being that will bring about social stability; and global competitiveness of the country that will attract investment. This work contributes to the R&D management knowledge base on roadmapping and future thinking at industry level.

1. Introduction

During 2016 the Department of Science and Technology in the South African government commissioned the development of a South African Aluminium Industry roadmap. The challenge was to develop an industry-wide conjunctural roadmap. A conjuncture is the period during which the different social, political, economic and ideological contradictions that are at work in society come together to give it a specific and distinctive shape. Considering the dynamics of the South African socio-economic, political, environmental, labour, cultural and technological needs, this is a complex environment. This complexity is in particular brought about by changing economic paradigms, driven by structural reform. South Africa has a mix of economies and has to deal with models of capitalism shaped by participation of industry, labour and government. The aluminium industry roadmap has outcomes and impacts on business enterprises, the industry, people and the country. The roadmap thus had to be designed to lead to profit for enterprises that will generate employment, industry growth that will result in market leadership,
human well-being (without entering into the various multidisciplinary debates around the concept this is taken to generally mean sustainable livelihoods within sustainable human settlements) that will bring about social stability and global competitiveness of the country that will attract investment, both locally and from foreign sources. Roadmaps often depend on the customer for the roadmap. A custom-made model had to be found to do this roadmap, not at technology, product or company level, but to include the entire value chain in the aluminium industry. The roadmap had to support a vision for the entire industry. This vision was developed using future thinking principles. Furthermore, the model had to comply with best practice in roadmapping and specificities of the South African aluminium industry. A research based approach was necessary to develop a roadmap framework that built on the theories and practices of basic roadmapping, future thinking, visioning, complements, dynamic capabilities, platforms and ecosystems approaches. The research approach that was followed included a literature study on roadmapping practices, drawing from consulting experience, modelling, testing the model with a steering group of industry experts and applying it in developing the industry roadmap with a larger group of industry experts. The model was refined during its use. It led to an industry roadmap that was widely tested and subsequently finalised and adopted by all stakeholders.

2. Previous work in the area

A multitude of references is available in the literature on technology and product roadmaps, but industry roadmaps are not covered extensively, let alone conjunctural roadmaps.

A conjunctural analysis (Jessop, 2012) depends on an appropriate set of concepts for moving from basic structural features to immediate strategic concerns; the spatio-temporal horizons of action that define the conjuncture; a clear account of medium and long term goals that should guide strategy and tactics in the current moment and the ethico-political commitments that set limits to acceptable action in particular contexts. An important aspect of conjunctural analysis is that the levels of complexity that are involved prevent it from being reductionist. Although not elaborated upon further in this paper, the notion of “decent capitalism” (Dullien, S., Herr, H. and Kellermann, C., 2011) should be linked to the development of an industry roadmap in the context of its conjunctural impact. Closing the gap between the perspective of a single investor and a more systemic macro-economic perspective is crucial to making an industry work in a developing and transformational economy.

New integrated approaches where technology roadmapping and market requirements are integrated have recently been developed (Vishnevskiy, Karasev, and Meissner, 2016: 153). Most industry roadmaps are customised to the specific industry and country (or global industry) in which that industry exists (Aldaba, 2014); (PACIA, 2014); (Gao, Hensley and Zielke, 2014). They also vary significantly in content and style, ranging from presenting past data series or being forward-looking. Roadmaps have been used since the 1970s, but only in the early 2000s, they have been made popular as strategic planning tools (Phaal, Farrukh and Probert, 2001). The approach mostly adopted included an analysis of technology, products and markets. A typical roadmap (reproduced from Phaal, et al, 2004) is shown in Figure 1. This type of roadmap applies excellently to describing the way forward for an enterprise. The problem, however, is that very little is reported in the literature on the development of an industry roadmap model when an entire industry has to be aligned with the future.

![Figure 1. A typical roadmap.](image-url)

On the other hand, business models are covered extensively in the literature. A business model is strategy in action. It guides the enterprise in creating, delivering and capturing value (Battistella, De Toni, De Zan and Pessot, 2017: 65). Business model innovation and agility are increasingly embraced as strategic options of positioning the enterprise on the value chain where it can be most successful.

Roadmaps are forward looking by nature. To set the path for future action in an industry, a vision is required. This vision then guides the thinking along the better-known dimensions of a roadmap, being, market; product/service; technology/process; and knowledge. This vision represents a common focus which is essential to good roadmapping (Phaal, et al, 2016). Additionally, the vision directs the confluence of the social, political and economic forces of the conjuncture that impact on the roadmap.
Often complements or complementary assets are to be considered in a whole industry context when investment in one asset increases the return on the other. Two assets are said to be complements when investment in one asset increases the marginal return on the other, e.g. manufacturing capabilities, marketing channels, brand name, technology platforms, etc.

Looking at an industry-wide roadmap also requires that dynamic capabilities (Teece, 2010: 172) should be considered if the enterprise needs to sustain itself as markets and technologies change (Teece, 2010: 679). Dynamic capability includes the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. Dynamic capabilities enable firms to keep up with changing market needs and operating environments. This is part of continuous improvement of existing processes and products and normally include the reconfiguring of the asset base (Ellonen, H-K., Jantunen, A., and Kuivalainen, O., 2012: 43).

Supportive platforms refer to layers of infrastructure that impose standards on a system in which many separate entities can operate. It allows businesses to easily connect and build products and services on top of the platforms and co-create value, e.g. a digital platform used for sharing and transacting.

Business ecosystems are networks of organisations, including suppliers, distributors, customers, competitors, government agencies, involved in the delivery of a specific product or service through both competition and cooperation.

3. Research problem and research question

For the research being reported in this paper, the research problem is formulated as:

“Most roadmap models apply to technology or product futures inside the enterprise and are not adequate for application to an entire industry.”

The research question is:

“Can an industry roadmap model be developed, supported by a future thinking process that addresses conjunctural challenges of the industry?”

4. Industry roadmap model design

The research was aimed at using accepted technology management principles and foresight approaches to develop a model for an aluminium industry roadmap that could be used to direct policy, R&D, enterprise expansion, partnerships and investment. An industry roadmap may be perceived in different ways, depending on where the observer or stakeholder is placed in the industry.

4.1 The industry business space

The business space in which each enterprise in an industry operates can be described by the tetrahedron in Figure 2. Markets dictate products and services which derive their functionalities from the technologies and processes that are applied in their production. This is supported by human aspects of knowledge, including innovation and management that makes this business space operational. Together, the elements of this space constitute the basis for a business model, which describes where the enterprise is adding value on the industry value chain.

![Figure 2. The business space determining the enterprise business model.](image)

4.2 Towards an industry roadmap model

The industry roadmap model is based on the principle of individual enterprise business models that are projected onto the industry value chain as shown in Figure 3.

This is done for each market sector, e.g. in the case of the aluminium industry, construction, transportation, packaging, machinery and equipment, electrical and consumer goods for the aluminium industry. The concept of the industry model, building from the individual business models is summarised as:
Industry roadmap model = \( \sum \) Enterprise business models projected on the industry value chain

Figure 3. Individual enterprise business models making up the industry projected on the aluminium industry value chain

The industry roadmap model recognises roadmap boundaries that are informed by the particular characteristics and requirements of the South African aluminium industry and markets, the requirements from all stakeholders, including the government and society and the conjunctural priorities. These include the policy domain, social development, regional development, environmental constraints, industry growth needs and requirements for sustainable livelihoods and settlements. Industry contribution to creating well-being among all citizens is a priority. The energy footprint of the aluminium industry as well as its impact on water resources are critical boundary items to consider.

The industry roadmap model provides a view of how the different players in the industry may navigate the value chain as new areas of the value chain show business opportunity.

Figure 4. The aluminium industry roadmap model representing an integrated industry business space5. Getting to the vision - future thinking
This view of the industry roadmap model, however, addresses only the classical roadmapping levels of markets, products/services, technologies/processes and knowledge. These enterprises co-exist on a broader industry base which assists in determining their destiny.

The full set of components (units of analysis) of the industry roadmap model include: the market sectors and sub-sectors for the industry; products along the value chain (primary, value-added, semi-fabricated, fabricated, final); processes used in product manufacturing; knowledge required to sustain the market-product-process triangle; complements to support the business space (market-product-process-knowledge); dynamic capabilities (ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments) required; platforms (layers of infrastructure that impose standards on a system in which many separate entities can operate, allowing to easily connect and build products and services on top of the platforms and co-create value); and ecosystems (the context and position of the industry within the larger economy, and entities that it co-exists with). The final industry roadmap model with examples from the aluminium industry is shown schematically in Fig.4.

This industry roadmap model is now aligned with the vision determined by the industry and creates a mechanism and interventions of moving towards that vision. The future landscape for the aluminium industry in South Africa was analysed by applying future thinking in a visioning exercise. Several future mapping and foresight techniques were used. These included mind-time travel (Furey and Fortunato, 2014: 119), high level futures mapping using the futures triangle (Inayatullah, 2008: 4), anticipating the impact of emergent issues, using the future thinking triangle (Botha, 2016: 951), the futures wheel (Emergent Futures, 2009), the future thinking lens (Botha, 2016: 951), causal layered analysis (Inayatullah, 2007), high level scenario construction using narratives and metaphors, and choosing a preferred and likely future. The combination of these techniques and their role in shaping the future is shown in Figure 5.

Mind-time travel related to future mapping reveals the views of the past, present and future. The edge of disruption was determined by looking at the emerging technologies, behaviour and events through the future thinking lens and their impact and probabilities in mapping on the relevance matrix and their knock-on effects by doing the futures wheel. The vision was then formulated based on deepening the future through causal layered analysis (CLA) and doing scenario analysis based on the future thinking lens and selecting preferred futures. The vision now becomes the beacon for the roadmap which will inform strategy and policy to be adopted in the present through applying a back-casting approach. Strategic interventions that will assist the execution of the industry roadmap can now be defined, understanding the dynamics of the future landscape.

Figure 5. The future landscape and visioning.

5.1 High level futures mapping

The futures triangle (Inayatullah, 2008) was used in a slightly modified form as shown in Figure 6. Drivers, barriers and possibilities were identified.

Figure 6. Modified futures triangle, juxtaposing the future South African aluminium industry (SAAI) in context with the past, present and future.

Drivers include: High demand for socio-economic development and human well-being; policy for environmental protection and industry development; stabilisation of supporting ecosystems for energy supply, sustainable business development, environmental impact reduction and
logistics; and incorporation of new technologies and processes for exploiting the attractive physical properties of aluminium and related alloys.

**Barriers** include: High cost of energy and labour; non-availability of skills and human capital; difficulty of access to markets, limited market size and narrow focus; varying dynamics of regulation in the scrap market; lack of import restrictions and ageing infrastructure.

**Possibilities** include: Potential for social upliftment; sustainable and growing industry employment; supporting sustainable communities; new market opportunities and synergies between market segments; a large contributor to the circular economy; and potential for novel alloys, aluminium intensive products and generating and retaining intellectual property.

### 5.2 Emergent issues

In this future thinking approach, a space was created that is defined by a triangle with corners signifying technology, behaviour and events. These emerging technologies have the potential to become disruptive if they dramatically replace other technologies or create new markets that may put existing enterprises out of business. When looking at the behaviour of people, it is normally considered inside and outside (in the marketplace) of the enterprise. The idea is to identify new emerging customer or consumer behaviours that will influence the business and to investigate the change in work approach, value systems and management approaches in a diversified demographic workforce. Events may be predictable or unpredictable, include those that could be controlled or are uncontrolled, those that exhibit long term change or have abrupt impacts. Events are typically characterised as geopolitical, economic, natural, social or demographic.

Emerging market behaviour pertaining to the South African aluminium industry were found to be: New consumer and customer dynamics; potential increased social instability; political uncertainty putting new demands on decision making; increased environmental awareness and legislation; emergence of regional trade agreements; the long-term impact of China; and emerging African markets.

Emerging behaviour inside the enterprise servicing the aluminium value chain include: adopting a new notion of a stable professional workforce, given specialist mobility; adoption of innovative management styles; coordinated partnerships between labour, industry and government; making the workplace environment attractive to workers and youth development.

Emerging technologies that will have a definitive impact on the industry include fast advances in materials technology; a shift to new process technologies; design intensive product technology; environmental demands dictating product design; substitute materials that are a threat to aluminium; and composite materials, where aluminium is one of the component materials.

Emergent events were identified. On the geopolitical front, continued SADC (Southern African Development Community) stability is critical; and the impact of leadership changes in the region and globally may influence trade and markets. Economic events that will have an influence include credit downgrades; exchange rate fluctuation; trade relations; and market access. Natural events that will shape the future of the industry include climate change and the resultant stress on resources by prolonged drought. Social events such as the influx of foreigners as part of world-wide migration patterns may alter the workforce. Demographically, the generational spectrum, and especially the inclusion of the millennials, in the workplace will change management and production paradigms.

### 5.3 Relevance of emerging impacts

The impacts from emerging technologies, behaviours and events were contextualised by plotting them on an impact/probability matrix to indicate relevance. Emerging issues have a low impact, but a high probability and should be watched and managed carefully. Disruptive issues occur when both a high impact and a high probability is expected, and timeous action is required to deal with such disruption. It should be kept in mind that disruption can be both positive and negative. Wild cards have a high impact and a low probability. This means that they are taken note of as having potentially a large disruptive impact, but the likelihood of it realising is low. Weak signals are often overlooked, since they have a low impact and a low probability. However, with time, weak signals can turn into wild cards or even disruptive forces, should their progression not be traced.

### 5.4 Higher order impacts

The impacts described above are first order. All of them have higher order impacts or consequences. The futures wheel (Emergent Futures, 2009), as a structured brainstorming method, was used to organise thinking about future events, issues, trends, and strategy. It is typically used to think through possible impacts of current trends or potential future events; organising thoughts about future events or
trends; identifying potential consequences of a strategy; showing complex interrelationships and developing multi-concepts.

The next step in the visioning was to create a futures wheel for the SAAI to establish knock-on impacts of the high priority emergent elements. The most disruptive emergent technology, behaviour and event were chosen from where the emerging issues were plotted on the impact/probability relevance matrix. These were placed centrally in the futures wheel and expanded to determine the knock-on impacts.

The largest impacts of new process technologies will be exerted through new joining methods and additive manufacturing. Joining technology will improve the ability to make new aluminium parts and panels. This will result in new tooling development which will rely on skills in tooling design. Additive manufacturing will lead to customising parts, which will require a design capacity that will enable customised products. High level skills will be required to introduce additive manufacturing and to handle its knock-on effects.

The increasing environmental awareness in the marketplace for aluminium products will result in new consumer behaviour as well as the requirement for appropriate policies. New consumer behaviour will include the demand for more information on products. This will enable the consumer to select preferred “green” products. Innovative design will be required to produce these environmentally friendly products.

A new behaviour that enterprises operating in the aluminium industry should adopt is to work within the ambit of coordinated partnerships between labour, government and industry. This will avoid extended negotiations on remuneration increases, job levels, key performance areas, labour strikes and malicious damage to property. Two immediate requirements are supportive policies and stable industrial relations. Supportive policies will lead to investor confidence and subsequent investment. Supportive policies will also enable new trade agreements, that will open new markets and create jobs. Job creation will lead to a growing economy which in turn will address socio-economic disadvantages. New markets will demand new products or production of larger volumes of products that will inevitably lead to the requirement for new technologies. Stable industrial relations will lead to workforce development which in turn will result in greater productivity. Improved working conditions as an outflow of workforce development will lead to stability in the enterprise and the industry.

A demographic based event in the aluminium industry is that there will always be the challenge of a knowledge and skills gap to be guarded against. The skills gap will mean that there may not be knowledge transfer and that the workforce may be unemployable. With no knowledge transfer, no new development can be expected. This will lead to an uncompetitive enterprise or industry. Eventually this could result in loss of market and industry shutdown. An unemployable workforce will further lead to no industry growth, which will fuel social unrest and may result in the malicious destruction of infrastructure. The importance of having an appropriately skilled workforce is thus clear and the disruptive power of a skills gap should be avoided at all cost.

5.5 Imagining the future for the aluminium industry

The future thinking lens was constructed by “spinning” the technology-behaviour-events triangle in both a clockwise and anti-clockwise direction. This yielded narratives on change paradigms, governance systems, new technology innovation, creating user behaviour, social innovation and mitigating measures.

Technology influencing events lead to the development of governance systems. Energy efficient technology used in production methods has a positive impact on climate change. Aluminium increasingly replaces other materials in automobiles. New processing leads to new manufacturing technologies and additive manufacturing reduces the energy footprint. Governments apply COP21 and carbon pricing and emission trading targets are set. The aluminium industry meets its carbon budget. Substitution by aluminium of other materials leads to positive impact on the environment through light-weighting. Aluminium is increasingly specified as the preferred material for manufacturing. New aluminium-based alloys are developed and lead to economic benefit from improved performance and royalties from patents. Regional scrap collection and sorting lead to reduction in unemployment. This results from legislation on packaging material where aluminium becomes the material of choice.

Events influencing behaviour lead to change paradigms. Environmental awareness is increased by climate change as more and more people start feeling its effects. Downgrades from credit rating agencies of South Africa and other BRICS (Brazil, Russia, India, China, South Africa) nations, cause the exchange rate to weaken which forces buyers to focus on price. Political and industrial leadership changes result in uncertainty, but leads to better cooperation between government, industry and labour. Regional trade agreements are becoming the order of the day and trade on the Sub-Saharan continent picks up.

Behaviour influencing technology initiate new
technology innovation. The focus on price and the demand for cheaper products lead to the development of competitive production processes. Alternative materials and fit-for-purpose alloys are developed to improve existing aluminium-based alloys. The increased environmental awareness creates a demand for greener products that are recyclable. Lower CO₂ footprints are demanded by clients. Investment shifts to new, green technologies and renewable energy such as solar, wind, and even mini-concentrator solar power plants are used to power energy intensive processes in the aluminium industry value chain. Waste management technologies are improved to ensure a lower impact on the environment.

*Technology influencing behaviour* creates user behaviour. New aluminium alloys introduced in automobiles result in improved performance and fuel efficiency. Buyers are attracted to the lower cost and environmentally friendly products. Additive manufacturing is used widely and the demand for customisation increases. Recycling creates new product opportunities at lower cost. Buyers are influenced by environmental awareness and legislation.

*Behaviour influencing events* shift focus to social innovation. A major skills gap exists in the industry. This results in an influx of foreigners with skills and drastic improvement of education programmes. Political uncertainty and increased social instability lead to political and industry leadership changes. The price sensitivity in the market, exacerbated by fluctuating exchange rates and the threat of economic downgrade, and the choice consumers have in competitive offerings, together with an abundance of easily accessible information causes a user revolution, driven by demand for customisation, innovation and product life cycle support. The increasing regional trade causes a mobility of knowledge and people, and attention shifts from knowledge retention to maintaining a positive balance of knowledge in the aluminium industry. Emerging superpowers (such as China) invest in infrastructure development in the African continental aluminium industry, but opens intellectual property protection challenges. Focus shifts to balanced local skills development to include engineering, technical, management and business skills.

*Events influencing technology* lead to mitigating measures. The severe impact of high energy footprint industries and unacceptable levels of emissions and waste materials on climate change results in the promotion of aluminium materials benefits. Local production of aluminium-based products such as air-conditioning heat exchangers to address global warming in general become in demand. The skills gap because of unbalanced education programmes is addressed, in particular in artisan training. A weak exchange rate of the South African Rand (ZAR) is exploited by increasing local production of materials and finished products for export. Political and industry leadership changes expected are exploited by presenting benefits of the aluminium industry to support new policy objectives.

### 5.6 Deepening the future

Causal layered analysis (Inayatullah, 2007) was used to deepen the future understanding. The visible (litany), *current state* of the aluminium industry was described as top heavy, little growth, low value addition, limited job creation, albeit stable business. The transformed view of the future is a balanced, sustainable aluminium value adding industry with job creation, a fast growth industry, supplying downstream enterprises with business opportunity. The *underlying system* for the current industry was outlined as operating at low economy of scale, experiencing low investment levels, and a large need for export required for sustained competitiveness. The transformed underlying system was defined as achieving sustainable high volumes supported by flexible government policies, leading towards greater local value addition. The *worldview* for the current industry is to a large extent that China rules, and that globally there are large protection and vested interests. The transformed view for the future industry includes the creation of level playing fields, and supplying regional, local and export markets.

### 5.7 Scenarios for the industry

High level scenarios were created for the industry based on those emergent elements that can be controlled (technology and behaviour) and uncertainties that result from events. The metaphor is a journey, and the first scenario where there is both control and certainty is the “Amazing Race”. The playing field is level and the industry can apply its mind to optimising its strengths and compete, going where its wants to go according to the plan. The second scenario where there is certainty but no control is “Quest”. There is certainty on where to go, but with no or very little control it remains a quest to arrive at the desired destination, continuously searching for the right path. Agility is required to continue moving forward. The third scenario is “Adventure”. There is strong control, but very little certainty. The industry can engage in hazardous and exciting activity, especially the exploration of unknown territory. The map can be drawn and tested in several ways. The fourth scenario is “Monte
Carlo”. There is no certainty and no control and everything remains a gamble or random walk. This requires “gutsy” optimism to stay in the game. The wild card scenario is “Stumbling stone”. This may get into the road and pose a danger of tripping or causing a fall. This is typically an environment where the industry considers something as having a very low probability of happening, but when it does, it is extremely disruptive. The South African aluminium industry is in control of its technologies and understands the behaviour of its people and markets. Certain major events, as identified above, may, however, increase uncertainty and lead to a most likely continued “adventurous” future. Ideally, the preferred future is to enter the “Amazing Race”, but this presupposes that events are understood, risks are quantified and mitigation is introduced. The aluminium industry is, however, not alone responsible for mitigating these future risks. The vision will pull the industry into this preferred future.

5.8 Vision driving the roadmap

The vision for the South African aluminium industry was then created that guided the roadmapping process and acted as the target for the industry roadmap model.

“The South African aluminium industry will become a competitive supplier of material (primary and secondary) and unique own finished products, growing to a net exporter through import replacement and localisation including regional and global markets. This will be achieved through growing capacity in the industry and optimisation of resources in an energy-efficient, sustainable and environmental friendly way, with significant job creation, socio-economic upliftment and resultant well-being for communities”.

6. Applying the industry roadmap model

The industry roadmap model and the vision were now combined to create an industry roadmap canvas.

6.1 Industry roadmap canvas

A SAAI Roadmap Canvas was developed as shown in Figure 7. The roadmap units of analysis derived from the industry model are listed on the left. The time zones are indicated for current (short) term (2016), medium term (2017 – 2020) and long term (2021 – 2030). The roadmap elements (content) should all be aligned to achieve the vision that was developed through future thinking.

![Figure 7. The industry roadmap canvas.](image-url)

6.2 Industry roadmap units of analysis

The roadmap units of analysis are now discussed.

The *market sub-sectors* are those that will drive the market sector contribution to the future of the aluminium industry as stated by the vision. These could be the natural outcome of extrapolation of the existing market drivers, or radically new ones that may support the market growth identified in local market dynamics.

This is followed by thinking about the *final products* that will push these market sub-sectors into the future or that will be developed as a result of the demand by future users. The feasibility of South African involvement in these products were considered on a continuous basis, to find products that will contribute to breakthroughs where players on the South African value chain could be leading edge or introduce new markets.

*Semi-fabrication processes* were subsequently considered at the generic level as outlined in Figure 4. The aluminium industry roadmap model representing an integrated industry business space. These processes are critical enablers for a wide variety of products identified. The *knowledge and skills base* is considered to ensure that the processes are optimised and efficient to lead to economic feasibility and sustainability. It is recognised that a large component of knowledge required for the future still has to be developed.

*Complements* that add to this knowledge base are then identified. These refer not only to agility towards market dynamics for individual enterprises, but the industry as a whole. Complements thus augment the knowledge and skills base to develop new processes (leading to new products) to respond to rapidly changing or radical emerging market conditions.
requirements.

Platforms that support business are then identified. These support the entire roadmap model towards the markets. These include enabling policies.

Ecosystems refer to the context and position of the aluminium industry within the larger economy. These ecosystems typically include competitiveness aspects and other influences.

### 6.3 Populating the industry roadmap canvas

The roadmap canvas, representing the roadmap model, was populated per market sector by doing group brainstorming and critical discussion. The first task was to determine market sub-sectors. The first part of this exercise dealt with the standard roadmap linking market sub-sectors, products, processes and knowledge over the timeline.

![Figure 8. Consolidated view of the roadmap for the SAAI in the construction market (the detail is obscured by the small font used and is not important here, only the visualisation is meant to be illustrated).](image)

The processes were treated as generic, as were the primary and semi-finished products and knowledge. Innovative thinking was required for finished products. These products were identified per market sub-sector.

To focus the discussion on the future and the vision, the task was designed to first look at breakthrough products that would realise the vision and market sub-sectors and products for the long term. Consolidated industry roadmap canvas content (Figure 8) was obtained by merging several expert workshop inputs for each market sector and by clustering elements together. The blocks of content per unit of analysis are now shown to proceed from the roadmap period in which it was initiated first and an arrow indicating if it proceeds towards the next time periods. These visualisations are the final outcomes of applying the industry roadmap model and were used as input into the development of the final SAAI roadmap.

### 6.4 Arriving at an industry roadmap

The consolidated inputs from experts, utilising the industry roadmap model, was used to visualise for each market sector over the time period chosen a winding road with many emerging opportunities and requirements for sustaining the industry. The roadmap highlights the present, then shows the medium term until 2020 and continues to the vision of 2030. Market sub-sectors for each of the six market sectors were identified and placed on the road ahead as signposts in the time brackets where they become important. The fabricated/final products that will become the leading industry winners were highlighted on the time frame of the roadmap. Drivers for each time period based on emergent issues are shown in support of the market sub-sectors and the fabricated/final products in specific time zones. This visualisation was done for all six market sectors considered as well as for the supporting processes, knowledge, complementary efforts, dynamic capabilities, platforms and
ecosystems. An example of the roadmap visualisation is given in Figure 9.

6.5 Interventions

An industry roadmap must influence policy and action. Specific interventions were identified from the industry roadmap and these were superimposed on the South African aluminium value chain and the time line of the roadmap. A summary of the roadmap outcome in terms of the vision elements, the interventions, achievements to focus on and goals reached is given in Figure 10. There are also designated reviewing points for the industry roadmap at the end of each time period. In addition to this, the roadmap remains a “living entity” that can be updated on a continuous basis, given shifts in the environment that influence the thinking. One of the key contributions the roadmap is making is to identify R&D needs for the industry. These are then translated into R&D projects which will be taken up by research institutions in the country such as universities and science councils.

6.6 Addressing the conjunctural priorities

Considering the impact of this aluminium industry roadmap on business enterprises, the industry, people and the country as a whole and expecting outcomes that will be beneficial, the roadmap is designed to lead to (see Figure 11) profit for enterprises that will generate employment; industry growth that will result in market leadership; human well-being that will bring about social stability; and global competitiveness of the country that will attract investment, both locally and from foreign sources, in the context of global capital forces. The roadmap is thus not a strategy, but will lead to many strategies for the conjunctural beneficiaries.

![Figure 11. Conjunctural nature of the South African aluminium industry roadmap.](image)

7. Conclusions

This research has led to an industry roadmap model that was theoretically designed, tested within a large and dynamic industry and practically applied to result in an aluminium industry roadmap at national level. It extended the traditional roadmap approaches focusing on markets, products and technologies to include the knowledge base, industry competitive aspects, the readiness of industry to change and expand, the impact on the environment and people closely involved with making the industry work and supporting the R&D and policy environments.

This model is flexible and could be applied to a wider industry base, has the ability to be customised based on applying well-known principles of strategic planning, future thinking and visioning and business model agility. The industry roadmapping model has large potential for further academic research and improvement, both in its structure and application. Many complex relationships that exist within an industry could be included in the model. Developing software that supports the model and presents the visualisations and automating inputs could also contribute to real time updating.

Implementing such an industry roadmap will require a thorough understanding of how to take traditionally conservative industries into the future. The roadmap should be applied to build relationships, allow competition and discourage collusion in terms of good governance in industry. One of the major challenges is how to keep the roadmap alive and dynamic. It should be updated regularly after identified periods, but the functionality is also needed to dynamically update
the roadmap, especially when disruptive influences are prevalent. Integration into the roadmap of previous industry reports, market analyses and studies is required. The role of a champion in taking a roadmap further to implementation cannot be underestimated.

The conclusion is that an industry roadmap model supported by future thinking and visioning can address conjunctural challenges of an industry and the country in which it operates. This work contributes to the R&D management knowledge base on roadmapping and future thinking at industry level.

8. Acknowledgement

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9. References


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