The need for PLM in South Africa

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Abstract. The South African engineering and manufacturing industries drive employment and growth in the economy, but face a large industrialisation and supplier development challenge in a globally competitive and knowledge intensive market. In order to enable industry participants and new entrants to deliver globally consumed products and services that are eco-friendly, regulatory compliant and sustainable, industry participants are urged to employ a Product Lifecycle Management (PLM) approach. PLM streamlines the flow of multi-disciplinary information about products, services and related processes throughout a complete product lifecycle, to ensure that the right information is available in the right context and at the right time. This paper motivates the need for increased adoption of PLM in South Africa, by showing potential benefit to selected South African engineering and manufacturing industries.

Introduction

Unemployment is unsustainably high in South Africa. Unfortunately, South Africa's economy is growing at a slower rate than expected and needed. In order to combat poverty, draw unemployed South Africans into economic activity, and generate the revenue needed to support the government's long-term development plans, a substantially higher rate of growth is needed. The National Industrial Policy Framework (NIPF) has consistently made it clear that manufacturing has a vital role to play in driving employment and growth in the economy (Department of Trade and Industry, 2007). The Industrial Policy Action Plan expands on this and has the following key objectives (Department of Trade and Industry, 2013):

- To promote diversification beyond the economy's current reliance on traditional and non-tradable services through the promotion of value-addition, characterised particularly by the movement into non-traditional tradable goods and services that can compete effectively in export markets and against imports.
- To promote a labour-absorbing industrialisation path, with the emphasis on tradable labour-absorbing goods and services and the systematic building of economic linkages that create employment.
- To promote industrialisation characterised by increasing participation of historically disadvantaged people and marginalised regions in the industrial economy.
- To contribute towards industrial development in Africa, with a strong emphasis on building the continent's productive capacity and securing deeper regional economic integration.
- To ensure the long-term intensification of South Africa's industrialisation process and movement towards a knowledge economy.

Manufacturing is the sector that offers the greatest potential to create jobs at respectable pay levels for the unskilled and semi-skilled. A strong and healthy manufacturing sector requires a positive approach to bring about an environment conducive for manufacturing investment, to grow the economy and create jobs. Due to the recession of 2009 many people have lost their jobs, many small business owners have closed their doors and the number of companies going insolvent is far too high (Stewart Jennings, 2012).

A strong and growing manufacturing sector is of vital importance for a prosperous South Africa. The Manufacturing Circle highlights the following statistics (Stewart Jennings, 2012):

- The manufacturing sector in SA employs around 1.7 million people;
- Manufacturing output accounts for approximately 15% of GDP, although the World Bank has shown that this has decreased to below 12% in 2014 (Trading Economics, 2015);
- For every R1 invested in manufacturing there is R1.13 of value addition to the SA economy;
- Manufacturing is among the top three multiplier sectors in terms of value addition, job creation, export earnings and revenue generation;
- Manufacturing provides the base load and scale for key national infrastructure such as electricity generation and municipal services;
- Manufacturing provides the only viable means of beneficiating natural resources in SA.

Problem Statement

The growth and competitiveness of manufacturing in South African has dramatically decreased over the last two decades, negatively affecting the national import versus export ratio (Pillay, 2013). This in turn has led to fiscal deficit, job losses and decreased economic growth. In response, the government has placed renewed focus on localisation through the Industrial Policy Action Plan (IPAP). This plan identified the following 16 industry sectors to be targeted for governmental support in an attempt to increase local production (Department of Trade and Industry, 2013):

- Clothing, textiles, footwear and leather;
- Automotive products, components, medium/heavy commercial vehicles;
- Plastics and pharmaceuticals;
- Metals fabrication, capital and rail transport equipment;
- Agro-processing;
- Forestry, timber, paper, pulp and furniture;
- Business process services;
- Creative industries: Crafts, music and film.
- Green & energy-saving industries;
- Downstream mineral beneficiation;
- Upstream oil & gas services and equipment;
- Boatbuilding.
- Nuclear;
- Advanced materials;

- Aerospace and defence;
- Electrotechnical and ICT.

Modern manufacturing is complicated though, with globalisation calling for more specialised facilities and production lines. Even though the product itself may be quite simple, the production process and supply chain may be complicated. It has been shown that even traditional products are rapidly increasing in intricacy, due to the need for customisation, personalisation, sustainability and the addition of electronic equipment (Vermaas et al., 2009). Figure 1 illustrates the increasing complexity of products.

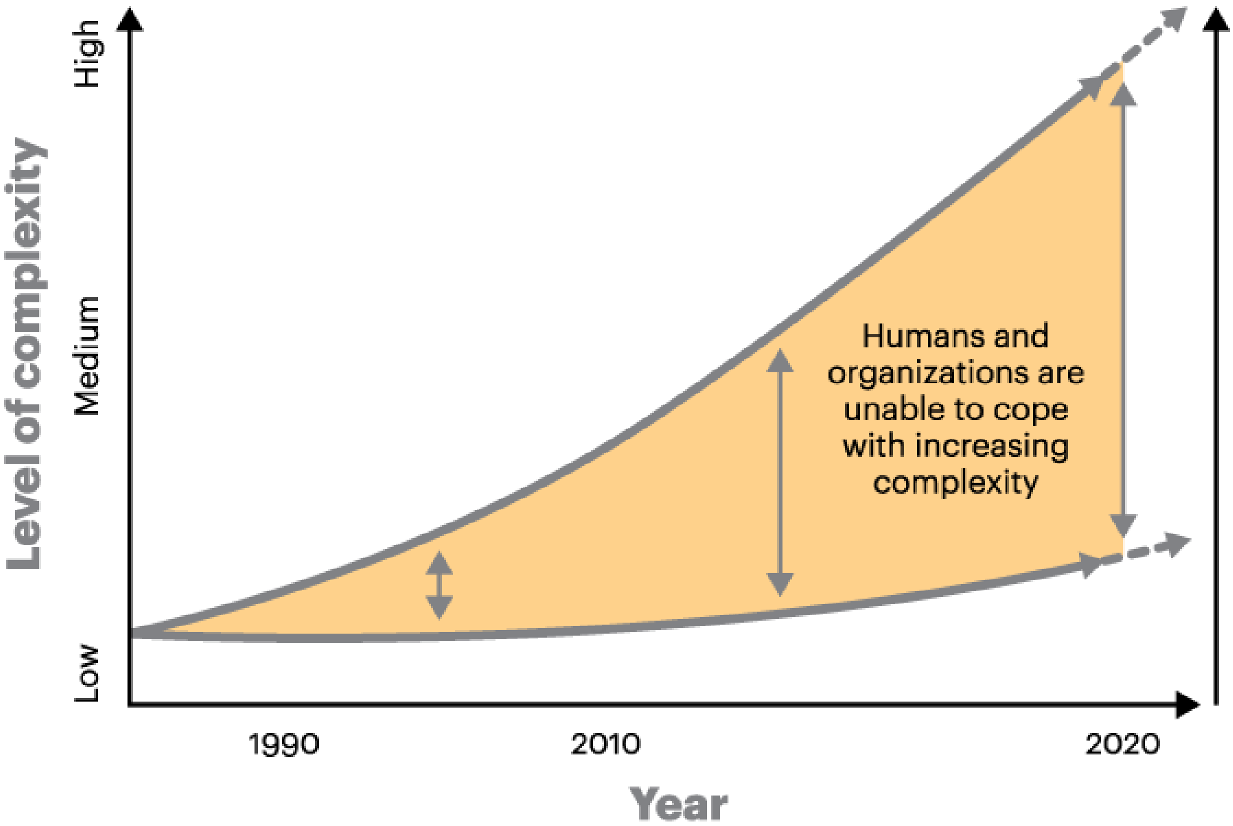

Figure 1: Increasing levels of complexity (Scheel et al., 2010)

As a brief example of the increase in complication, modern luxury vehicles have code executing more than 50 electronic control units, with code bases in the order of one hundred million lines of code. Industry analysts calculate that 40% of the market value and 80% of automotive innovation is now computer based, making software a major contributor to the price and value of a vehicle (Reyes, 2014). It is not unusual for Tier 1 OEMs to employ several hundred software engineers to develop, integrate, and test software.

To deal with this growing problem, the automotive industry responded with collaboration and cooperation, by establishing the AUTOSAR alliance with the mandate to cooperate on standards and rather compete on implementation (Daehyun Kum et al., 2008). The primary goal of the consortium is to remove the proprietary solutions and enable standardised, productised and predictable software products. The objective of the AUTOSAR software architecture is to provide a clear separation from the application (differentiation) and the infrastructure (commodity) domain.

Not only does product complication constantly increase, the business environment also becomes more complex. The rapid globalisation not only offers the opportunity of a more diverse set of potential suppliers and customers, but also brings new competition (Stark, 2011). Unfortunately though, a globalised market also introduces more complication in the form of differences in regulations and cultural norms between countries and regions.

A more complicated product also results in a more complicated supply chain. As products become more sophisticated, engineering and manufacturing enterprises have to become more specialised. Modern products go through several stages of integration and assembly, with the original equipment manufacturers aggregating components, subsystems or even entire systems from many suppliers (Gandhi, 2013). The product of one enterprise is often one of several inputs into the production process of another enterprise. Or the product of one company is used to support the product of another company. For example, the lifting jacks designed and manufactured by company A is used to maintain the locomotives produced by company B, which is in turn operated by company C. To maintain product quality amongst overlapping suppliers, it becomes even more important to evaluate each supplier and establish valuable relationships.

Engineering of complicated products

With the exponential increase in the complication of products, the systems approach to product development, realisation, utilisation and support increases in importance (Erasmus and Doeben-Henisch, 2011). The discipline of systems engineering is quite proficient at addressing complicated products with a large number of components and interfaces. It has managed to adapt the older subject field of systems theory into a practical methodology of specifying and verifying complicated systems (INCOSE, 2015). The discipline also takes into account the need to address manufacturing, utilisation and support considerations early in the product development phase of the system lifecycle, although it struggles with enterprise-level systems (Erasmus et al., 2015).

Compared to the more traditional engineering disciplines, such as civil and mechanical engineering, systems engineering is certainly a younger sibling, born from the exponential increase in the complexity of modern products (Cogan, 2012). Though it is not clear exactly how and where the practice of systems engineering started, the complexity of aircrafts led the military to adopt a systems thinking and analysis approach, accelerating the development of systems (Cogan, 2012). Many government departments of the United States of America have adopted systems engineering and even made it mandatory for contractors to follow their methodology (INCOSE, 2011).

Systems engineering has become almost standard practice in several industries, beyond the traditional aerospace and defence applications. Commercial entities have increasingly adopted the systems engineering approach over the decades, due to the following three factors (Kossiakoff et al., 2011):

- The rapid advancement of technology introduces more technical risk in the development of a product, which requires technical management;
- Fierce competition forces system-level trade-offs to produce superior products; and

- Increased specialisation requires a more modular system which can be designed and produced by different parties, which makes stringent interface management necessary.

With the release of the international standard ISO/IEC 15288 in 2002, systems engineering is now the preferred practice for the development of complex products, especially those requiring multiple engineering disciplines (INCOSE, 2011). It should be noted that systems engineering is concerned with the definition of a product which will satisfy the stakeholder expectations and the validation of the product, but not with the physical creation of the product (US Air Force, 1969). However, the verification that the product was created as defined by the systems engineering effort and validation that the product satisfies the original need, does fall within the scope of systems engineering (IEEE Computer Society et al., 2005).

The systems engineering discipline is mature and positioned well to deal with the development and integration of modern, complicated products, but it has enjoyed minimal adoption in most industries in South Africa. Where it has seen adoption, it is seen as a supplementary practice, often resulting in a constrained or partial implementation.

In the South African context

Even though fourteen of the sixteen industries identified by IPAP require modern engineering and manufacturing techniques, the four industries where South Africa competes most visibly in the global market are highlighted here to identify the real problems encountered in these industries.

Automotive

Strong competition and high level of customer expectations in today's global automotive market have forced organisations to strive for shorter product development cycles by focussing more on their supply chains (Manzouri et al., 2010). Supply chain management integrates supply and demand management within and across companies as a collaborative approach that includes various role players in the supply chain. These players significantly contribute to improved product quality, shorter lead times, and a higher responsiveness, at lower cost and improved customer satisfaction levels (Bennett and O'Kane, 2006; Humphreys et al., 2007; Lockström et al., 2009).

The South African automotive industry has grown to become the leading manufacturing sector in the economy. Even though the industry is very competitive and many world class management practices are already in use in the industry, the business environment has changed over the past few years. There is pressure on South African automotive component manufacturers (ACMs) to compete with the best in the world from a cost and quality perspective in order to survive (Ambe and Badenhorst-Weiss, 2011). The automotive industry is under severe pressure and faces many supply chain problems that are a result of rapid developments in supply chain management, technological advancements, high labour costs, poor infrastructure, globalisation and increasingly demanding customers who are squeezing their suppliers on price and non-price factors (Naude, 2013). The role of ACMs in the competitiveness and the survival of the automotive industry is vital, as ACMs are the main contributors to employment in the automotive industry and they can make a great contribution to the cost competitiveness of the South African automotive industry (Naude, 2013).

Aerospace

Some of the challenges for the South African aerospace sector include (Kraemer-Mbula, 2008):

- The changing nature of aerospace manufacturing: major changes in global production chains are increasingly demanding higher technological capabilities;
- The ability of domestic aerospace companies to adapt to the new terms of global competition and to upgrade the manufacturing capabilities of lower-tier suppliers;
- The integration of aerospace manufacturing into domestic supply value chains: technological capabilities in these sectors still remain insufficient while most of the production is exported instead of incorporated into domestic advanced manufactures.
- The complex nature of aerospace and its traditional connection to the state: creating an adequate regulatory environment for aerospace. Close collaboration between government, industry, academia and research institutions is a key element to improve the industry's competitiveness.

Mining

Supply chain management entails an integrative and systems philosophy of managing the total flow of a distribution channel from suppliers to ultimate user. A typical supply chain comprises suppliers of raw materials, manufacturers, retailers and consumers. The ultimate objectives of a supply chain are ensuring customer satisfaction, improving quality, reducing cost and improving services. Key role-players in the South African coalmining industry include mining companies, government departments responsible for minerals and environmental affairs, domestic and export coal customers, rail transport services, and the main coal export facility at Richard Bay Coal Terminal (Pooe and Mathu, 2011). The following inefficiencies have been observed in the mining industry:

- The supply and quality of coal remains problematic and has caused power stations to operate well below their capacity, resulting in revenue losses.
- Features such as strategies, technologies, people and systems (Pooe and Mathu, 2011).
- Increasing formalisation and integration among collaborating organisations
- Supply chains provide logical platforms for collaborations.
- The success of collaboration largely depends on technology. The benefits span from raw material suppliers to customers. It brings down inventory, increases forecast accuracy and increases revenue to customers.
- Effective collaboration is a source of competitive advantage which aims to improve customer service, profit generation, asset utilisation and cost reduction.

Agribusiness

Several managers of South African agribusiness have highlighted the following three key challenges facing the industry sector beyond 2000 (Darroch, 2010):

- Lower trade barriers and the ability of well-resourced multinational firms to transfer technology, marketing and management know-how from country to country at relatively low cost have led to increased global competition (Darroch, 2010);
- An organisation requires specific abilities in order to successfully form and manage supply chains, including a focus on holistic systems that integrate the whole supply chain and an emphasis on product and service quality and quality assurance (e.g. food safety) along the supply chain, (van Duren and Sparling, 1998; Boehlje et al., 1999; Tan, 2001);

- Overcoming barriers to successful supply chain management, such as the lack of communication and information flow across the players in the chain (van Duren and Sparling, 1998; O'Keeffe, 1998; Boehlje et al., 1999).

The future of supply chains

From these brief investigations of four major industries in South Africa it is clear that supply chain management is causing significant problems. South African companies are struggling to maximise benefit from their supply chains due to poor communication and information sharing between participants in the supply chain. Considering that products are becoming more complicated and supply chains larger with more specialised suppliers, the problems experienced with supply chain management will continue to worsen. Original equipment manufacturers will become more dependent on suppliers to deliver high quality components and services. As components become more intricate and sophisticated, the engineering and manufacturing will happen more in the supply chain, rather than within the customer-facing enterprise.

Previously, companies mass-produced products anticipating sales. However, in today's highly competitive global economy, the consumer's higher expectations are driving demand for customisation. The prospering companies are those that truly understand their markets and the individual needs of each customer. The world has shifted, creating the rise of customer power and influence.

Improving visibility throughout the supply chain remains a top objective (Barloworld Logistics, 2014). As businesses become more integrated both internally and externally, with key suppliers and service providers, supply chain visibility will naturally increase. There is recognition that supply chains vary according to the needs of the product, service or customer. Each supply chain requires effective alignment, integration, management and visibility in order to sustain the levels of customer service demanded today.

PLM as an enabler

With the increased need to integrate design packages and components from numerous suppliers, the importance of supply chain integration also increases. Traditionally, this portion of the practice has been lacking, with most of the focus placed on the management of requirements and the product configuration. Product lifecycle management has the potential to increase the scope of systems engineering. Through the improved sharing and exchange of product information between suppliers and integrators, the reach of systems engineering discipline extends beyond the traditional enterprise. It also holds the potential of extending the reach of systems engineering discipline to the utilisation and support phases of the product, by creating a more direct link between the utilised product and the design authority, through technologies such as the Internet-of-Things.

Fourteen of the sixteen commodities and products of IPAP require modern engineering tools and techniques, necessitating collaboration between several parties. This collaboration is facilitated by the exchange of information between the different organisations. For this reason, several international tier-one original equipment manufacturers have started integrating their supply chains by encouraging their suppliers to use the same product lifecycle management (PLM) software suites. For example, Boeing expects all the suppliers for the 787 Dreamliner to work with a specific set of PLM software, making it easier to standardise on design information, specifications, engineering rules, operational parameters and simulation results across the extended enterprise (Feller, 2004). Some have even gone as far as hosting a platform for all its suppliers to work in. Such a common platform holds many benefits for parties involved, especially in supply chains that are geographically dispersed.

The adoption of product lifecycle management as a business approach and the use of the related software suites are struggling to gain support and traction in South Africa (Slansky, 2014). This makes it difficult for local manufacturers to complete in the global market and maintain proper control of their products as it progresses through the different life stages. It also makes it difficult for local engineering and manufacturing organisations to participate in certain high-technology industries, such as automotive and aerospace.

Product Lifecycle Management (PLM) is a business solution which aims to streamline the flow of information about the product and related processes throughout the product's lifecycle such that the right information in the right context at the right time can be made available (Ameri and Dutta, 2005). It is a software-enabled strategy to improve processes to conceptualize, design, develop and manage products, driving higher levels of product profitability. PLM enables three types of integration, along the following axes:

- PLM addresses the entire lifecycle of a product and the associated information from conception through design and development, release to manufacturing, after-sales service (asset, operation and maintenance management), disposal and obsolescence.
- PLM allows for improved collaboration between practitioners from different disciplines and business functions.
- PLM integrates people, data, processes and business systems to provide a product information methodology for the company and its extended enterprise.

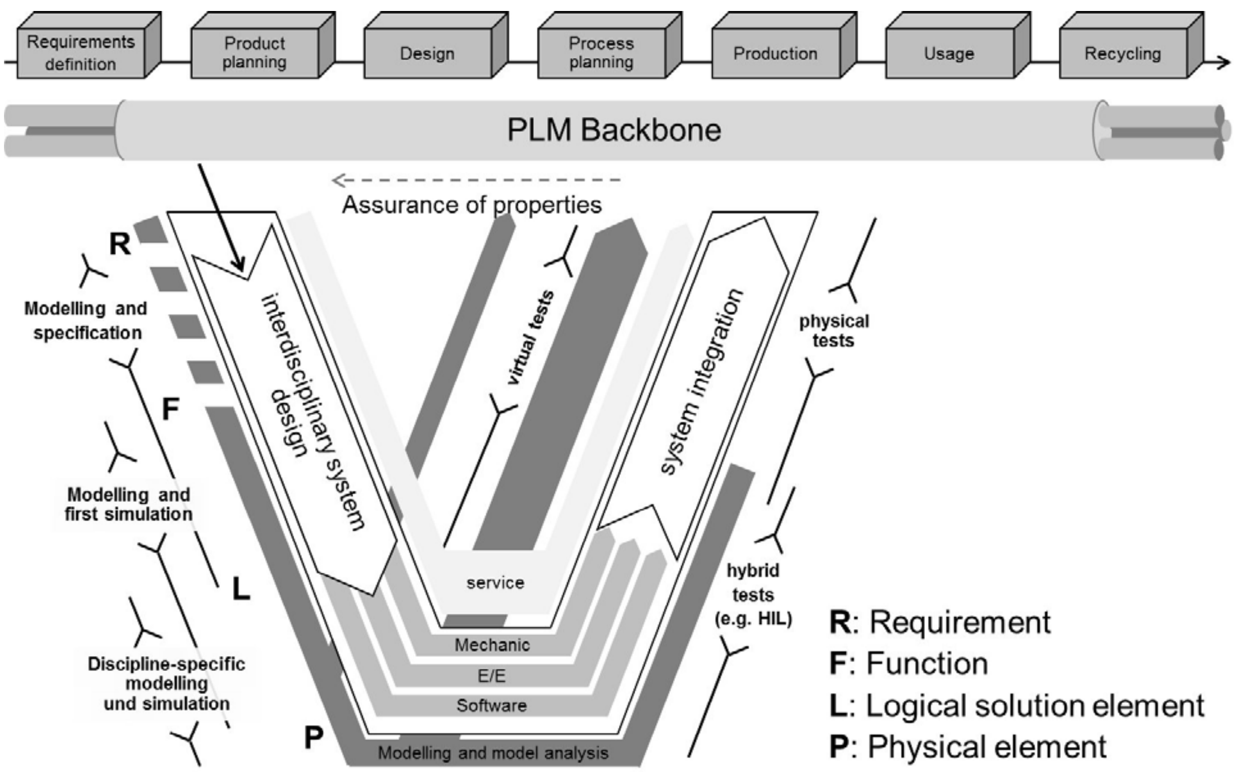

Figure 2: PLM and the systems engineering V-model

Figure 2 shows how PLM aligns to the V-model to enable systems engineering. PLM delivers the following values (Stark, 2011):

- Manage the product portfolio and maximise financial return;
- Providing control and visibility over products throughout the lifecycle;
- Managing product development, support and disposal projects effectively;
- Managing feedback about products;
- Managing intellectual property;
- Enabling multi-disciplinary design and with supply chain partners;
- Managing product-related processes so that they are effective;
- Capturing and maintaining the integrity of product definition information;
- Knowing the exact characteristics of a product throughout its lifecycle (Stark, 2011).

By comparing the aforementioned industry challenges with the various solutions that PLM can offer, it seems to be a single solution to a multitude of problems. PLM can be integrated into most discreet industries (aerospace, mining, agribusiness and automotive) and is the mechanism which facilitates the relationship between the various participants in the supply chain, by enabling the exchange of the information that describes the product, its configuration and intended use.

Conclusion

In order to put South Africa on a higher, job-rich growth path, and enable us to compete and succeed as a manufacturing destination in the global economy, the manufacturing industry must be developed to maintain proper control of their products as it progresses through the different life stages. PLM streamlines the flow of multi-disciplinary information about products, services and related processes throughout a complete lifecycle, to ensure that the right information is available in the right context and at the right time.

With the product, the business environment and the supply chain rapidly increasing in complexity, good systems engineering discipline is crucially important to deliver products which satisfy customer expectations. This paper positions PLM as an enabler for systems engineering, by empowering the discipline and extending the techniques to all product lifecycle phases and across the supply chain. However varied the industries their products, by simply acknowledging the benefits of PLM within an industry that requires development, it can be seen that there does indeed exist a need for PLM in South Africa.

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Biography

Jonnro Erasmus has worked as an industrial and systems engineer in the electricity, transport and manufacturing industries. He has also had the responsibility of managing interdependent risks between major construction projects of both public and private enterprises. He specialises in the use of requirements and functional analysis to identify risks and opportunities in business systems and engineering organisations. Jonnro holds a bachelor of engineering from the University of Pretoria and a master of engineering from the University of Johannesburg. He is also a registered professional engineer with the Engineering Council of South Africa.

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Louwrence Erasmus worked for more than 20 years on multi-disciplinary projects in academia, South African and international industries. He is a Principal Systems Engineer at the CSIR since 2013. He is an advisory board member of Third Circle Asset Management. He graduated from the Potchefstroom University with the B.Sc., B.Eng., and M.Sc. degrees in 1989, 1991, 1993 and was awarded a Ph.D. degree in 2008 from North West University, Potchefstroom. He is a registered professional engineer with ECSA and a senior member of IEEE and SAIEE. His interest is formal structures using constructivist philosophy of science and their practical implications in the practice of systems engineering.