CONCEPTUAL FRAMEWORK TO MANAGE COMPLEXITY WHEN INTRODUCING TECHNOLOGICAL CHANGE TO AUTOMOTIVE PRODUCTION LINES

OTTO, WILLEM LIEBRECHT
Stellenbosch University, Department of Industrial Engineering, South Africa
liebrecht.otto@gmail.com (Corresponding)

OOSTHUIZEN, GERT ADRIAAN
Stellenbosch University, Department of Industrial Engineering, South Africa
tiaan@sun.ac.za

ABSTRACT

Manufacturing has experienced multiple revolutions and paradigm shifts and in recent years competition has become truly global. Never before have companies needed to adapt as quickly to market requirements and to adopt new technologies as speedily as today without the risk of being relegated to irrelevance.

Daimler AG recently decided to introduce Hybrid vehicles to the East London factory of its subsidiary, Mercedes-Benz South Africa (MBSA). The C350e would pioneer ‘high-voltage automotive manufacturing’ in South Africa as it would be the first hybrid vehicle produced on the continent. The new variant would introduce to MBSA a powerful Lithium-Ion battery that is capable of producing 60kW and operating at 300V – a voltage potentially lethally high. The factory was given less than a year to prepare for this car and to integrate this dangerous new technology at a level meeting the stringent international safety and quality standards of Mercedes-Benz. No local automotive original equipment manufacturer (OEM) had any experience with ‘high voltage automotive manufacturing’ prior to the implementation decision taken in Germany and the safety risk initially met significant resistance in the South African factory. The risk and the associated resistance had to be carefully managed by the Implementation Team against the backdrop of a lack of applicable safety legislation in the country.

While there have been many frameworks put forward to manage change, there is no framework available to guide automotive OEMs to introduce technological change to their production lines safely, effectively and efficiently. The objective of this research is to understand the complexity of change management and specifically the aspects applicable to introducing technological change to production lines. The final purpose of which is to identify key elements necessary to formulate a conceptual framework to aid manufacturers with these type of implementation projects and processes, finally focussing on the high voltage systems needed to produce hybrids and/or electric vehicles (EVs).

In 2009 a Consolidated Framework for Implementation Research (CFIR) was developed for the healthcare profession. It is the goal of this paper to lay the foundations for what would be further developed into a similar framework for the automotive sector. The Implementation Framework for Automotive Technology (IFAT) will consolidate the myriad of different yet overlapping concepts and bridge their individual shortcomings to offer an overarching solution to introducing a new technology to an automotive OEM’s production lines safely, effectively and efficiently and offer countermeasures to the additional complexity originating from said introduction.

To formulate a holistic understanding of the complexities of Change Management, specifically the aspects relevant to introducing technological change to automotive production lines to the extent that an Implementation Framework can be built from that foundation, an extensive literature study of the most widely respected and referenced Change Management models was done. The models were examined for both linear and non-linear concepts that could be applicable to automotive manufacturing plants and a meta-theoretical construct was created through a snowball sampling approach combing the applicable elements of all the models. This construct was further 'snowballed' with aspects of Implementation Science frameworks, non-codified theory and the researchers' own experience implementing technological change.

The five-step foundational approach created from this study was tested against the introduction of AMG units to the East London factory of Mercedes-Benz South Africa and found to be largely effective. Areas of future improvement were suggested to further mature the framework before it will be tested against the introduction of potentially dangerous technologies like 'high voltage automotive manufacturing'.

Key words: Automotive; Technology Implementation; High Voltage; manufacturing; Change Management

INTRODUCTION

Manufacturing has experienced multiple revolutions and paradigm shifts and in recent years competition has become truly global. Never before have companies needed to adapt as quickly to market requirements and to adopt new technologies as speedily as today without the risk of being relegated to irrelevance (Oosthuizen & Otto, 2017). Mega-trends like climate change, the ever-increasing demand for mobility (particularly in China) and the threat of Peak Oil, are driving change in the automotive sectors to new heights – particularly in the directions of e-mobility solutions (Neugebauer, 2017). There often remains a gap though between the inherent value of a technology and organisations' ability to effectively put it to work. With looming global competition the gap between a technology's promise and achievement is a major concern for all companies.

It has been shown that after organizations develop new technologies they generally hand them off to users who, though knowledgeable and experienced in the areas of planned application, are less technically skilled in the technology. The user organization is often not willing or even able to take over responsibility for the new technology at the time that the development team wants to hand it over and is also often not yet able to optimally put it to work at this time (Leonard-Barton & Kraus, 1985).

Daimler AG recently decided to introduce Hybrid vehicles to the East London factory of its subsidiary, Mercedes-Benz South Africa (MBSA). The C350e would pioneer 'high-voltage manufacturing' in South Africa as it would be the first hybrid vehicle produced on the continent. The new variant would introduce to MBSA a powerful Lithium-Ion battery that is capable of producing 60kW and operating at 300V – a voltage potentially lethally high.

The factory was given less than a year to prepare for this car and to integrate this dangerous new technology at a level meeting the stringent international safety and quality standards of Mercedes-Benz. No local automotive original equipment manufacturer (OEM) had any experience with 'high voltage automotive manufacturing' prior to the implementation decision taken in Germany and the safety risk initially met significant resistance in the South African factory. The risk and the associated resistance had to be carefully managed by the Implementation Team against the backdrop of a lack of applicable safety legislation in the country (Department of Labour, 1983) (van Rooyen, 2016).

While there have been many frameworks put forward to manage change, there is no framework available to guide automotive OEMs to introduce technological change to their production lines safely, effectively and efficiently. The objective of this research is to understand the complexity of change management and specifically the aspects applicable to introducing technological change to production lines. The final purpose of which is to identify key elements necessary to formulate a conceptual framework to aid manufacturers with these type of implementation projects and processes, finally focussing on the high voltage systems needed to produce hybrids and/or electric vehicles (EVs).

Change, although it can often be emergent, can also be managed. Change Management is the study of "moving an organization from an old state to a new one in a planned way" (Green, 2007). Kurt Lewin pioneered the field in 1951 when he theorized three main stages of change: 'unfreezing' current practices, implementing the required changes and 'refreezing' the organization. The more modern "8-Steps for Leading Change" Model (Kotter, 1996) argues that to best overcome the known resistance to change and in order to effectively lead change one should start by creating a sense of urgency around an idea or opportunity and then build a powerful guiding coalition, in terms of titles, information, relations and expertise. Next one needs to create a vision of the change and remove obstacles to the change process, be they individuals, systems or processes. One should then plan for and create short-term 'wins' to demonstrate the benefits of the change. The final steps are to consolidate the improvements and sustain the movement before cementing the change and the process of change as an organizational culture. It argues that by effectively leading change one can overcome the inherent resistance thereto.

The Aachen Innovation Model (AIM, or W-Model) proposes 7 steps to Kotter's 8. These 7 steps are:

1. **Goal Setting** – defining the strategic direction and innovation objectives of the initiative based on the enterprise's overall objectives and strategy.
2. **Future Analysis** – identifying and analysing different innovation opportunities that could potentially lead to new product development activities.
3. **Idea Generation** – generating specific product ideas based on the opportunities identified in the previous phase. Ideas are systematically and consistently organised based on the information required to plan for and evaluate them.
4. **Idea Evaluation** – identifying those product ideas with the greatest potential to fulfil the innovation objectives (set out during *Goal Setting*). Ideas are assessed for their organisational, market, competition and technological (or technical) feasibility.
5. **Detailing Ideas** – developing detailed product concepts for the feasible product ideas.
6. **Concept Evaluation** – quantitatively evaluating the product concepts using the criteria of the *Idea Evaluation* phase and the verified information of the *Detailing Ideas* phase. Concepts are selected that are technically and economically feasible and aligned with enterprise strategy.
7. **Implementation Planning** – assimilating the activities of the pervious phases by providing a systematic guide for implementing the selected product concepts – referred to as an Innovation Roadmap.

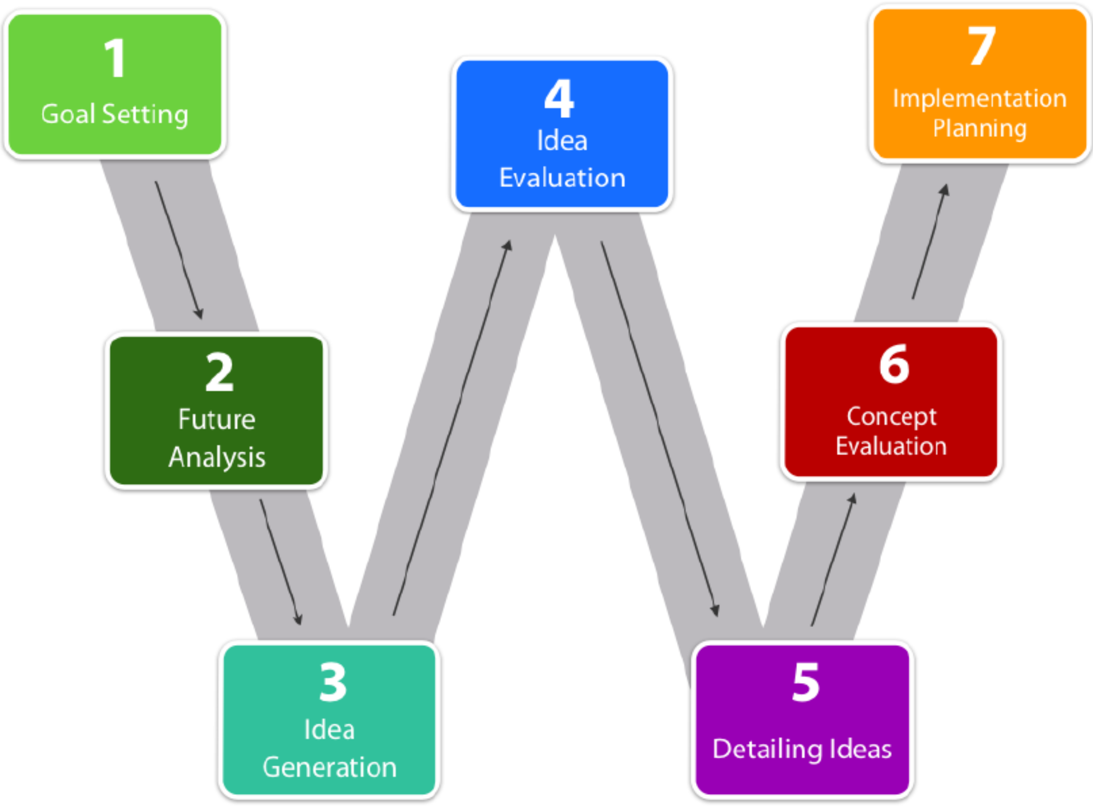

Figure 1: The Aachen Innovation or "W-Model" (Enterprise Engineering Group, 2009)

It is interesting to note that in both of these respected models, the actual implementation step is very loosely defined. Kotter's first step is to create a sense of urgency, yet only by step six does one see anything implemented and even then only a pilot. The W-Model waits until the very last step to do "Implementation Planning" and does not directly address the implementation itself.

What is Implementation then? "Implementation is the constellation of processes intended to get an intervention into use within an organization: it is the means by which an intervention is assimilated into an organization. Implementation is the critical gateway between an organizational decision to adopt an intervention and the routine use of that intervention; the transition period during which targeted stakeholders become increasingly skilful, consistent, and committed in their use of an intervention. Implementation, by its very nature, is a social process that is intertwined with the context in which it takes place" (Damschroder, et al., 2009).

While Change Management theory is very useful in a broad sense, the fact that in large, multinational companies like automotive OEMs, the decision making team, the technology development team and the implementation team might not even reside on the same continent, effectively rules out certain steps from these models, or alters them significantly from the initial intent. What is missing in the literature is a hands-on framework for the implementation of technological change in automotive production lines – something an Implementation Team can practically use to safely, effectively and efficiently introduce a new technology in an automotive manufacturing plant and manage or mitigate the associated rise in complexity.

RESEARCH METHODOLOGY

Implementation Science is "the scientific study of methods to promote the systematic uptake of research findings and other EBPs (evidence-based practices) into routine practice, and, hence, to improve the quality and effectiveness of health services" (Bauer, et al., 2015).

The words theory, model and framework are often used interchangeably in literature, although they are distinct concepts. A theory normally implies a level of predictive capacity, a model is commonly created to describe a process, while a framework points to factors believed/found to influence outcomes. Both models and frameworks are typically like a checklist of factors or aspects relevant for the implementation being described. Models often "present an ideal view of implementation practice", while many frameworks draw extensively from the originator's own experience implementing new practices. It can easily be argued that what matters most isn't the nomenclature of the construct as there is significant overlap, but that the objective of paramount importance is to identify potential enablers and barriers to the implementation and to describe ways to deal with them effectively. There is a wave of optimism currently in Implementation Science that thinks theoretical approaches can contribute to narrowing the research-practice gap. Some critics believe theory isn't necessarily better than 'common sense', though that in itself can be said to be a form of non-codified theory (Nilsen, 2015). It is the writers' belief that the answers lie in a combination of codified and non-codified theory, amalgamated with implementation experience.

In 2009 a Consolidated Framework for Implementation Research (CFIR) was developed for the healthcare profession (Damschroder, et al., 2009). It is the goal of this paper to lay the foundations for what will be further developed into a similar framework for the automotive sector. The Implementation Framework for Automotive Technology (IFAT) will consolidate the myriad of different yet overlapping concepts and bridge their individual shortcomings to offer an overarching solution to introducing a new technology to an automotive OEM's production lines safely, effectively and efficiently and offer countermeasures to the additional complexity originating from said introduction.

To formulate a holistic understanding of the complexities of Change Management, specifically the aspects relevant to introducing technological change to automotive production lines to the extent that an Implementation Framework can be built from that foundation, an extensive literature study of the most widely respected and referenced Change Management models was done. The models were examined for both linear and non-linear concepts that could be applicable to automotive manufacturing plants and a meta-theoretical construct was created through a snowball sampling approach combing the applicable elements of all the models. This construct was further 'snowballed' with aspects of Implementation Science frameworks, non-codified theory and the researchers' own experience implementing technological change.

The search for relevant theories, frameworks and other inputs was non-exhaustive, but a saturation point was reached for the IFAT's foundation. It is anticipated that, once developed, the IFAT will keep evolving as other researchers use it and contribute additional knowledge and experience to the Framework. The first development step would be a case study testing the aforementioned foundations against another implementation project at MBSA's East London factory.

LITERATURE STUDY

The following twenty three Change Management theories formed the foundation of the IFAT:

- ADKAR Model (Hiatt, 2006)
- Accelerating Implementation Methodology (Implementation Management Associates, n.d.)
- Beckhard & Harris Change Process (Becker & Harris, 1998)
- Boston Consulting Group Change Delta (Boston Consulting Group, 2013)
- Bridges Transition Model (Bridges, 1991)
- Burke-Litwin model (Burke & Litwin, 1992)
- Conner's Stages of Commitment (Conner & Patterson, 1982)
- The Change Leader's Roadmap (Ackerman Anderson & Anderson, 2001)
- GE's Change Acceleration Process (CAP) (Six Sigma Institute, n.d.)
- Kotter's 8 Step Model for Change (Kotter, 1996)
- Kubler-Ross Change Curve (Kubler-Ross, 1969)
- Lewin's Three Stage Change Model (Lewin, 1947)
- LaMarsh Managed Change™ Model (LaMarsh Global, n.d.)
- McKinsey 7S Framework (Peters & Waterman, 1982)
- Nadler Tushman congruence model (Nadler & Tushman, 1980)
- Nudge Theory (Thaler & Sunstein, 2008)
- People Centered Implementation Model (Miller, 2011)
- Prosci Enterprise Change Management (Prosci, n.d.)
- Prosci Change Management Levers (Prosci, n.d.)
- Rogers' Diffusion of Innovation Model (Rogers, 1962)
- Satir Change Model (Satir, et al., 1991)
- Viral Change Roadmap Model (Viral Change Global, n.d.)
- Weisbord 6 Box Model (Weisbord, 1976)

The theories can be split into four categories:

i. Change uptake concepts
ii. Psychological change experience models
iii. Organisational change capability models
iv. Linear change methodologies

Change uptake concepts (i)

Not everyone adopts change at the same pace. Figure 2 depicts the Diffusion of Innovation in a norm distribution. Rogers' proposes five different groups when it comes to change uptake, namely Innovators, Early Adopters, the Early and Late Majority and Laggards (Rogers, 1962). Each group has unique characteristics that should be managed accordingly.

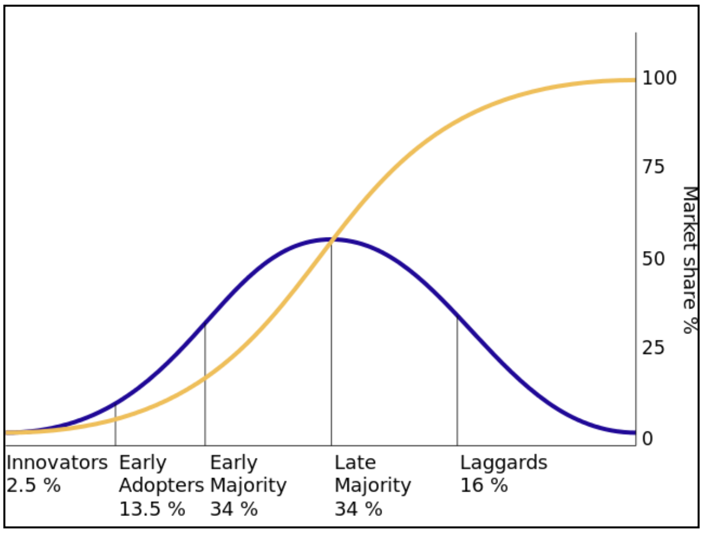

Figure 2: Rogers' diffusion of innovation (Rogers, 1962)

Psychological change experience models (ii)

Figure 3 depicts the Kubler-Ross Change Curve. Kubler-Ross theorises that for most individuals the experience of 'Change' runs through a number of stages, comparable to the well-known "5 stages of grief". It is important for an Implementation Team to understand that feelings of shock, denial, frustration and even forms of depressions are normal to some extent when dealing with change management and that they as custodians of the Change Management process must deal with these negative feelings appropriate to avoid disruption of the implementation.

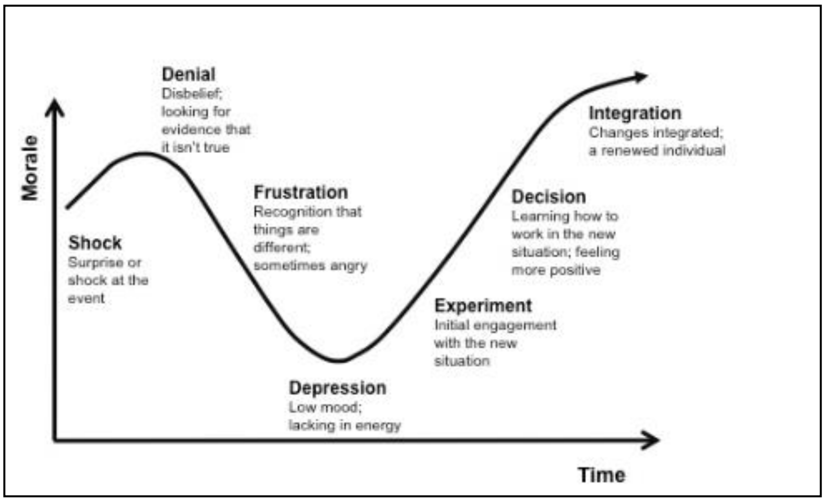

Figure 3: The Kubler-Ross Change Curve (Kubler-Ross, 1969)

Organisational change capability models (iii)

The People Centered Implementation Model proposes six 'Critical Success Factors', while the Prosci model theorises five 'Change Management Levers'. The overlap in the constructs is self-evident.

Prosci change lever	PCI Critical Success Factor
Communications lever	Shared Change Purpose
Sponsor roadmap lever	Effective Change Leadership
Coaching lever	Powerful Engagement Processes
Training lever	Committed Local Sponsors
Resistance management lever	Strong Personal Connection
	Sustained Personal Performance

Table 1: Prosci and PCI models for organisational change capability (Prosci, n.d.) (Miller, 2011)

A consolidation of these and other aspects critical to successful implementation will be incorporated into the IFAT to enable Implementation Teams to safely, effectively and efficiently introduce technological change to automotive production lines.

Linear Change Methodologies (iv)

Linear Change Methodologies provide a step-by-step approach to Change Management. The W-Model's 7 stages and Kotter's 8 steps can be overlapped with the 9 phases of the Change Leader's Roadmap (Table 2) to formulate the linear aspects forming the foundation of the IFAT.

Change Leader's Roadmap phase
Phase I – Prepare to Lead the Change
Phase II – Create Organizational Vision, Commitment & Capability
Phase III – Assess the Situation to Determine Design Requirements
Phase IV – Design the Desired State
Phase V – Analyze the Impact
Phase VI – Plan & Organize for Implementation
Phase VII – Implement the Change
Phase VIII – Celebrate and Integrate the New State
Phase IX – Learn and Course Correct

Table 2: The 9 phases of the Change Leader's Roadmap (Ackerman Anderson & Anderson, 2001)

FOUNDATIONS OF THE IMPLEMENTATION FRAMEWORK FOR AUTOMOTIVE TECHNOLOGY

While the evaluated linear models lack depth with regard to aspects of successful implementation, the non-linear models provide insight into these success factors, but lack a step-by-step approach. To create a meta-theoretical construct, elements of all four the aforementioned categories are required.

These elements must be combined with countermeasures to rising complexity in order to create the IFAT and to ultimately assist the industry with technology implementation.

The IFAT is envisioned as a linear framework, with non-linear additions for increased effectiveness. The amalgamation of the various linear models studied led to the five foundational steps of the IFAT depicted in Figure 4.

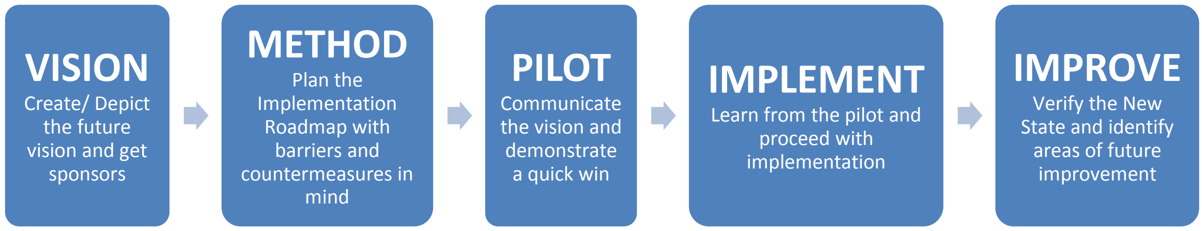

Figure 4: The five foundational linear steps of the IFAT

The non-linear Change Uptake, Psychological Change Experience and Organisational change capability models show that a key factor in successful implementation is the effectiveness with which change resistance is managed. It is known that the size of the organization, the resources available to it and the support of its management has an impact on the adoption of new technologies (Yin, 1977). It is also known that once an adoption decision has been made, the attitude of management and the ultimate users' perceptions of the technology play a large role in the implementation success. Generally, the higher the level of the managers that define the problem or the need for implementation, the greater the probability that the organization will implement it. Both their superiors (if any) and their subordinates need to buy into the concept in order for it to succeed, although the ways of communicating to the various levels will be different. Strong sponsors must be obtained in the Vision step and be kept on board for the duration of the implementation. In the case of automotive OEMs it is best that the sponsors be a coalition of local and international leaders. The Implementation Team, together with the sponsors, should clearly show the Vision of the future and clarify the reason for implementation as well as the benefits thereof. While "Opinion Leaders" can sway general sentiment, it is known that strong Sponsorship creates upfront buy-in and significantly reduces the resistance to the change.

The Implementation Team also needs to have targeted approaches for the various groups to manage them through the change curve experience during implementation. The Innovators generally need little encouragement, but should be cautioned on the negative aspects or dangers of the new technology, lest they in their haste cause accidents that will inevitably delay or cancel the implementation. This can be incorporated into the Vision and Method steps of Figure 4, but must be reinforced until after the Implementation step.

Opinion leaders can be used both for communication and resistance management. Frequently opinion leaders aren't in formal executive positions, but hold their place of influence due to technical proficiency or seniority in the company. Getting an opinion leader to buy into the implementation can go a long way into convincing others. Often this requires little more than a well-presented training session and a clear demonstration of the benefits (Enterprise Engineering Group, 2009). Early

Adopters can be used as Opinion Leaders to influence the Majority, both Early and Late, who need to be convinced of the benefits of the change to facilitate on-time implementation. Opinion Leaders should be identified in the Method step, while the Pilot step should be used to bring the Majority into the fold.

The Implementation Team should bear in mind that most, if not all, people will experience the emotions associated with the Kubler-Ross curve and some frustration and/or lack of cooperation should be expected. The Laggards will eventually adopt the technology too, once they are convinced the Implementation step was done properly and the technology is safe to use. Some Laggards will only come on board after the Improve step, once all the wrinkles are ironed out.

Training can be both an Enabler and a Barrier to Implementation. It should be planned in the Method step and effected during the Pilot and Implementation steps. The people impacted by the implement of the new technology should be thoroughly and properly trained to effectively and efficiency utilise it. This will also aid to institutionalise the change. At the same time it is important to train not only the people who will be working directly with the technology, but also their supervisors. Not training the supervisors can easily disconnect the various levels and cause the technology to be rejected by middle management (Leonard-Barton & Kraus, 1985). Effective training will facilitate an effective Pilot step and demonstrate the benefits of the new technology. It can also be used to bring the Laggards on board and be used in the Improve step to further the efficiency of the newly introduced technology.

CASE STUDY AND AREAS OF FUTURE DEVELOPMENT

The foundation of the IFAT was tested against the introduction of AMG vehicles in the East London factory of Mercedes-Benz SA. The project introduced several hundred new parts, chief amongst them were the introduction of v6 and v8 engines. While this was not a substantially different technology to the current vehicles being built by MBSA, it would serve as a test of the applicability of the IFAT and be used to identify the gaps still to be filled by future research.

Similarly to the C350e Hybrid Project, the AMG Project started with an implementation decision in Germany, not South Africa. Daimler AG decided in late 2016 that East London would have to build AMG products from 2017 onward to meet rising global sales demands. The Implementation Team was handed this challenging 'Vision' and proceeded quickly to depict it locally and get both local and international sponsors on board. While planning the Implementation Roadmap, the team realised that although the v6 units can be introduced relatively easily, the v8's have too many unique parts that were not yet available in South Africa. To overcome this barrier a decision was made to create a two-stage implementation, introducing the v6 units in the middle of the year and the v8's towards the end.

The Implementation Roadmap, along with the vision, was communicated to the broader factory early in 2017 and by March a Pilot build was done to verify the Bill of Material and the readiness of the various work stations.

From the test vehicles built during the Pilot stage or "Engineering Trial", it was identified that some equipment would need to be upgraded as it could cope with small, batch production, but would not keep up with series volumes. Gaps in training and work stations imbalances were also identified and corrected.

The Implementation step consisted of three Production Trials before the factory would finally officially start series production of the v6 units. The lessons learnt from this phase of the project was used to ‘Improve’ the project plan and build improved v8 trials. The v8’s were ‘Piloted’ shortly after the series introduction of the v6’s and the next iterations of trials were done to bring these units also to the international standards of Mercedes-Benz.

It was noted that while the foundational steps of the IFAT served as an excellent procedural guideline it lacks specific countermeasures to increased complexity. It was suggested by the Implementation Team that the increase in complexity be studied further and that specific countermeasures be listed for increases in structural, product and/or process complexity.

It is further suggested that KPIs (Key Performance Indicators) or some form of review be incorporated in the Framework to verify effectiveness and/or efficiency.

CONCLUSION

The globally competitive nature of manufacturing in the current age has placed strong focus on the pervasive gap between the inherent value of a new technology and organisations’ ability to put it to work effectively. At the same time global mega-trends is driving change in e-mobility solutions to new heights, while user organisations are often not able to take over technologies quickly enough from their developers to truly keep up with the pace of development.

Prompted by the development of the CFIR developed for the healthcare profession, the researchers studied various Change Management models to identify linear and non-linear aspects applicable to introducing new technologies in the production lines of automotive OEMs to start to create an Implementation Framework for Automotive Technology.

A snowball sampling approach was followed to create a meta-theoretical construct of applicable elements from over twenty well known and referenced models and further improved on with aspects from Implementation Science frameworks, non-codified theory and the researchers’ own experience introducing technological change.

The five-step foundational approach created from this study was then tested against the introduction of AMG units in the East London factory of Mercedes-Benz South Africa and found to be largely effective, though areas of future improvement were suggested.

The foundation of the IFAT has been laid. Once matured, the framework will be tested against the introduction of high voltage technology required for the manufacture of hybrid and electric vehicles, but the next step must first be to mature the framework, specifically with regard to countermeasures to increased complexity and measurements of efficiency.

REFERENCES

Ackerman Anderson, L. & Anderson, D., 2001. *The Change Leader's Roadmap.* San Francisco: Wiley.

Ashley-Roberts, C., 2015. *Kubler-Ross change curve.* [Online]
Available at: https://www.linkedin.com/pulse/all-change-charlotte-ashley-roberts/
[Accessed 18 November 2017].

Bauer, M. S. et al., 2015. An introduction to implementation science for the non-specialist. *BMC Phychology,* 3(1), p. 32.

Becker, R. & Harris, R. T., 1998. *Organizational transitions : managing complex change.* 2nd ed. Reading: Addison-Wesley.

Boston Consulting Group, 2013. *The Importance of Change Management,* s.l.: Boston Consulting Group.

Bridges, W., 1991. *Managing Transitions: Making the Most of Change.* s.l.:s.n.

Burke, W. W. & Litwin, G. H., 1992. A Causal Model of Organizational Performance & Change. *Journal of ManagemenT,* 18(3), pp. 523-545.

Colledani, M. et al., 2016. Design and management of reconfigurable assembly lines in the automotive industry. *CIRP Annals,* Volume 65, pp. 441-446.

Colwell, B., 2005. Compexity in Design. *IEEE Computer,* 38(10), pp. 10-12.

Conner, D. R. & Patterson, R. W., 1982. Building commitment to organizational change. *Training & Development Journal,* 36(4), pp. 18-30.

Damschroder, L. J. et al., 2009. Forstering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implementation Science,* 4(50).

Department of Labour, 1983. *Occupational Health and Safety.* [Online]
Available at:
http://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjdobC2js3OAhXKJcAKHRVvDqMQFggdMAA&url=http%3A%2F%2Fwww.labour.gov.za%2FDOL%2Fdownloads%2Flegislation%2Facts%2Foccupational-health-and-safety%2Famendments%2FAmended%
[Accessed 4 June 2016].

Elmaraghy, W., Elmaraghy, H., Tomiyama, T. & Monostori, L., 2012. Complexity in engineering design and manufacturing. *CIRP Annals - Manufacturing Technology,* 61(1), pp. 793-814.

Enterprise Engineering Group, 2009. *Enterprise Engineering Textbook.* Stellenbosch: University of Stellenbosch.

Green, M., 2007. *Change Management Masterclass.* s.l.:Kogan Page.

Gyulai, D., Kadar, B., Kovacs, A. & Monostori, L., 2014. Capacity Management for Assembly Systems with Dedicated and Reconfigurable Resources. *CIRP Annals,* Volume 63, pp. 457-461.

Hiatt, J. M., 2006. *ADKAR.* s.l.:Prosci Learning Centre.

Hu, S. J., Zhu, X., Wang, H. & Koren, Y., 2008. Product variety and manufacturing complexity in assembly systems and supply chains. *CIRP Annals,* Volume 57, pp. 45-48.

Implementation Management Associates, n.d. *The AIM Change Management Methodology.* [Online]
Available at: https://www.imaworldwide.com/aim-change-management-methodology
[Accessed 3 October 2017].

Kleinhans, M., 2016. *High Voltage logistics* [Interview] (25 February 2016).

Kotter, J., 1996. *Leading Change.* Boston: Harvard Business School Press.

Kubler-Ross, E., 1969. *On Death and Dying.* s.l.:s.n.

LaMarsh Global, n.d. *What is Managed Change.* [Online]
Available at: http://www.lamarsh.com/about/successful-change-management/
[Accessed 15 October 2017].

Leonard-Barton, D., 1988. Implementation as Mutual Adaptation of Technology and Organization. *Research Policy,* 17(5).

Leonard-Barton, D. & Kraus, W. A., 1985. Implementing New Technology. *Harvard Business Review*, November.

Lewin, K., 1947. Frontiers in Group Dynamics: Concept, Method and Reality in Social Science; Social Equilibria and Social Change. *Human Relations,* 1(1), pp. 5-41.

Mariotti, J. L., 2008. *The Complexity Crisis.* s.l.:Adams Media.

Miller, D., 2011. *Successful Change: How to Implement Change Through People.* s.l.:BookPOD.

Mourtzis, D., Doukas, M. & Psarommatis, F., 2013. Design and operation of manufacturing networks for mass customisation. *CIRP Annals,* Volume 62, pp. 467-470.

Nadler, D. A. & Tushman, M. L., 1980. A model for diagnosing organizational behavior. *Organizational Dynamics,* 9(2), pp. 35-51.

Neugebauer, R., 2017. *E-Mobility - Technological trends and challenges,* s.l.: s.n.

Nilsen, P., 2015. Making sense of implementation theories, models and frameworks. *Implementation Science,* 10(53).

Oosthuizen, G. A. & Otto, W. L., 2017. *Managing complexity while introducing high voltage technological change into production lines of globally competitive automotive manufacturers.* Vanderbijlpark, 28th Southern African Institute for Industrial Engineering Annual Conference.

Peters, T. J. & Waterman, R. H. J., 1982. *In search of excellence.* s.l.:s.n.

Prosci, n.d. *Enterprise Change Management: An Overview.* [Online]
Available at: https://www.prosci.com/change-management/thought-leadership-library/enterprise-change-management-overview
[Accessed 3 November 2017].

Prosci, n.d. *Five Levers of Organizational Change Management.* [Online]
Available at: https://www.prosci.com/change-management/thought-leadership-library/five-levers-of-organizational-change-management
[Accessed 3 November 2017].

Rogers, E., 1962. *Diffusion of Innovations.* 5th ed. s.l.:Simon and Schuster.

Satir, V., Banmen, J., Gomori, M. & Gerber, J., 1991. *The Satir Model.* Palo Alto: CA: Science and Behavior Books.

Six Sigma Institute, n.d. *Change Acceleratino Process.* [Online]
Available at: https://www.sixsigma-institute.org/Six_Sigma_DMAIC_Process_Define_Phase_Change_Acceleration_Process_CAP.php
[Accessed 14 June 2017].

Thaler, R. H. & Sunstein, C. R., 2008. *Nudge: Improving Decisions About Health, Wealth, and Happiness.* New Haven: Yale University Press.

van Rooyen, G., 2016. *Hybrid Safety* [Interview] (17 March 2016).

Viral Change Global, n.d. *How Viral Change™ works.* [Online]
Available at: http://www.viralchange.com/how_does_viral_change_work.html
[Accessed 7 November 2017].

Weisbord, M. R., 1976. Organizational Diagnosis: Six Places To Look for Trouble with or Without a Theory. *Group & Organization Studies,* 1(4), pp. 430-447.

Weyand, L. & Bley, H., 2010. *Considering Worst-Case scenarios within final assembly planning.* Vienna, Austria, s.n.

WikiMedia, n.d. *McKinsey 7S Framework.* [Online]
Available at: https://upload.wikimedia.org/wikipedia/commons/e/e7/McKinsey_7S_framework.svg
[Accessed 25 November 2017].

Yin, R. K., 1977. Production efficiency versus bureaucratic self-interest: two innovative processes?. *Policy Sciences,* 8(4).