UNIVERSITY OF WARWICK

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1465783

Enhancing UK Manufacturing Productivity by enabling a Value Chain Orientation

WMG
Innovation Report

Engineering Doctorate
Academic Year: 2014 - 2019

Academic Supervisor:
Prof. Dr. Janet Godsell
Prof. Dr. Jay Bal
Industrial Supervisor:
Mark Abramo
May 2019

WMG
THE UNIVERSITY OF WARWICK

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WMG
Engineering Doctorate Portfolio

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This thesis is submitted in partial fulfilment of the requirements for the degree of Engineering Doctorate
(NB. This section can be removed if the award of the degree is based solely on examination of the thesis)

Abstract

Supply - Demand mismatch is a continuous challenge among suppliers creating poor customer service levels and often leading to higher costs to the entire supply chain, to meet the demands of the customer. This research was carried out in the context of a steel supplier (TATA Steel) having supply issues with one of its premier automobile customers (JLR), due to difficulties in forecasting the appropriate demand from the customer.

The outcome of the research was developing a framework for an integrated planning process that overlooks the entire demand planning and management of the customer. This particular research emphasises the application of demand profiling that enabled the researcher to build a novel future state Inventory model based on “Fixed Order Cycle” and “Fixed Order Quantity” methods that resulted in saving 24% of inventory across the value chain.

In the course of this research, one case study at two companies were performed enabling to draw a big picture map of the current planning process between the two companies. In addition to designing a future state map based on demand, supply and inventory parameters of planning processes between the two companies. Additionally, a maturity assessment framework was developed based on an Enabler and Inhibitor analysis, which study structure and processes within and between firms and identify any business implications that affect the performance of these companies.

The key innovations presented in this research led to new supply chain segmentation principles in an end-to end value chain involving two companies in a single business context, which has limited research to date. The segmentation methods addressed in this research provide companies significant business benefits in not only minimising inventory but also fostering new integrated planning activities by demand signals which are visible from the initial phase of planning and across the downstream processes in the SC. The impact of the research on one hand is that the supplier can market themselves to be a champion performer with higher customer service levels and lower failed delivery issues whilst, the customer has no production stoppages by optimal material availability that are available on time and in full.

List of Abbreviations

ADI	Average-Demand Interval
ARMITTS	Central Warehouse
B&W	Body and White
BOM	Bill of Materials
BOS	Basic Oxygen Steel Making
BPM	Big Picture Map
BTO	Build to Order
CIM	Centralized Inventory Management
CR	Continuous Review
CV	Coefficient of Variation
ERP	Enterprise Resource Planning
FG	Finished Goods
FP	Factory Planner
IT	Information Technology
JIT	Just in Time Delivery
JLR	Jaguar Land Rover
MA	Moving Average
MES	Manufacturing Execution System
MOQ	Minimum Order Quantity
MRP	Materials Requirement Planning
MTO	Make to Order
MTS	Make to Stock
OEM	Overall Equipment Manufacturer
OFID	Order Fulfillment and Delivery
OPP	Order Penetration Point
OTIF	On Time – In Full
RM	Raw Materials
S&OP	Sales and Operation Planning
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SKU	Stock Keeping Units
ToC	Theory of Constraints
TS	Tata Steel

Declaration

I have read and understood the rules of plagiarism and cheating as outlined in the Engineering Doctorate's handbook and I declare that this work is my own, unless otherwise acknowledged.

Rajesh Shankar Priya

29.05.2019

Acknowledgements

I begin my acknowledgements with an ancient Indian (Sanskrit) text, quoted from the Vedas:

"om ajnana-timirandhasya jnananjana-salakaya
caksur unmilitam yena tasmai sri-gurave namah"

"I was born in the darkest ignorance, and my teachers opened my eyes with the torch of knowledge. I offer my respectful obeisance unto them".

At this occasion, I would like to extend my sincere gratitude to my academic supervisor Dr. Janet Godsell for her continuous support to open my ignorant eyes, in the area of Supply Chain Management. She always wanted me to learn the skills in a scholarly way and make this education journey, in an enjoyable and meaningful way. She has been a guiding pillar for me in this long and uncertain journey for the past four years. I also extend my gratitude to Dr. Jay Bal who has mentored me in different occasions with deep insights on the research topic. My special thanks to Dr. Kate Bailey who single-handedly facilitated my research by coordinating with all the stake holders and helping me to gather all the data which was critical for the research. I also thank the efforts of Mark Abramo at TATA Steel and Matthew Stanton at JLR for the Industrial support and guidance. My special thanks to Vivienne for her kind support and friendship at WMG throughout this entire study.

My parents have sacrificed a lot in their lives to make me a person who I am now, and my elder brother Balaji has been a friend and mentor all these years. There has been not a single day in my life that has gone without their support, love and affection. I have never missed my parents here in the UK as our friends Shirley and Brian adopted us as their own children and took care of us in this country, which I am making it as my home. My extended gratitude to them for their unconditional love, care and support.

I am blessed to have children like Krishna and Keshav. They continuously teach me on human values of being kind, compassionate, tolerant and patient. They set unprecedented standards for me to lead a humble life and they are my real role models. Last but not least, my wife Gayathri is an angel in my life and without her association, love, care and motivation, my existence is void.

“To my ever-loving Krishna”

“To my Spiritual Master”

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1 Introduction

"If you can't explain to a six-year old, you don't understand it yourself"

Albert Einstein 1879 - 1955

Automotive suppliers often place top emphasis in matching supply and demand to satisfy the customer. However, most of them invariably struggle to solve the supply and demand challenge, creating a huge decline in customer service levels and ultimately losing market share and economic benefits, due to additional costs in meeting customer demands (Vitasek et al. 2015). Even in the 1960's, when the companies mainly focussed on solving process engineering challenges, the demand – supply mismatch was a strenuous issue for managers (Skinner 1986). Skinner (1970) predicted that there will be a long, continuous trade-off between customer requirement and satisfaction. However, customer satisfaction eventually got prioritized in subsequent terms, on-par with cost and quality in the manufacturing strategies around the 1990's (Leong & Ward 1995). Up until 1990's, cost and quality were the main pillars of manufacturing strategy and delivery performance was never an important attribute. However, Beamon (1999, p.275) claims that "*The global competition is not only based on product quality or cost but in combination with performance of the delivery*". Any supply chain management concept that enhances productivity is significantly dependent on strategic decisions taken along the value chain, with firm collaboration between companies that include joint planning, joint forecasting and managing inventory dynamics in a collaborative manner (Jones 1985; Houlihan 1988). However, most of the companies still plan independently with in their business units with no visibility in their own downstream processes. Despite numerous efforts taken by suppliers to forecast demand that can guarantee a stellar level of customer service, they recurrently face obstacles in the form of demand forecasting, planning and management (Stevens 1989), the prime reason being volatility and variability of demand that occurs within the entire value chain (Griffin-Cryan et al. 2011). While on one hand, the customer still shares information to the suppliers on demand and on the other, supplier forecasts the demand using forecasting tools, there is still a massive gap in demand and supply due to the accuracy of demand (Boylan et al. 2008). This research will implement the concept of inter-firm planning, mutual

sharing of information and managing automatic replenishment to improve performance on the entire value chain using demand profiling methods (i.e. including the demand information generated within the customer's downstream processes). This will enable the supplier to forecast the demand more accurately providing an enhanced delivery performance guaranteeing, no out of stock events to the customer while maintaining superior customer service, optimal inventory buffer and reducing the entire SC cost. This research will investigate the end to end planning capacities between two firms connected in a single SC. The framework developed during the course of this research will facilitate delivery performance ensuring efficient and robust supply of materials at the right time, in full and at the right location.

1.1 Outline of the Innovation Report

The outline of the innovation report is illustrated in Figure 1. Following the outline chapter, the rationale of research is discussed along with the research aim and objectives listed in section 1.3. The section 1.4 is dedicated to the value and scope of the research with section1.5 depicting the portfolio structure with the summary of the chapter listed in 1.6.

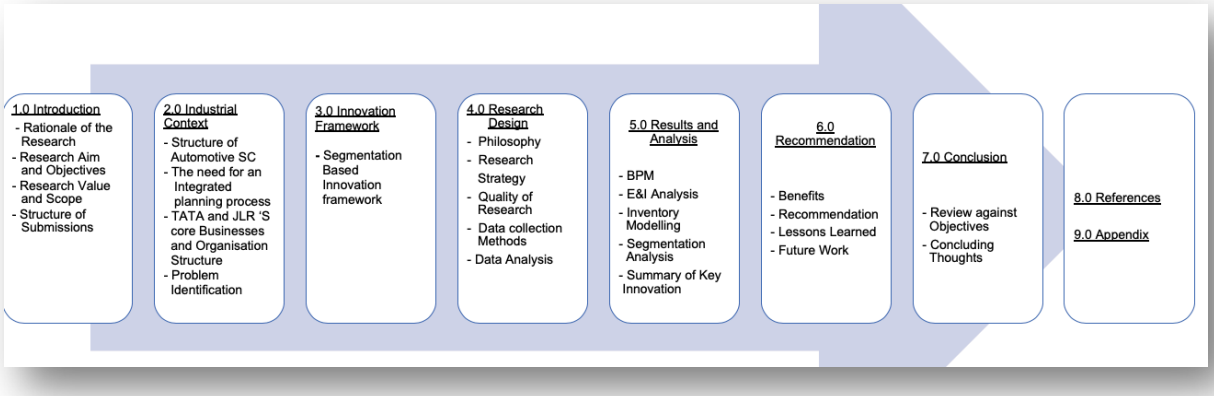

Figure 1: Outline of the Innovation Report and Introduction Chapter

In chapter 2.0, the industrial context of this research work is highlighted with the structure of the automobile supply chain. The preamble to this research context is presented in 2.1, while the section 2.2 studies the structure of the companies and section 2.3 explains the need of an integrated planning system in the context of this

research. The focus then shifts to the individual company backgrounds in section 2.4 that includes the organisation structure, collaboration modus and their core businesses. The segmentation-based Innovation framework is outlined in Chapter 3.0. The research methodology is highlighted in chapter 4.0 with the philosophy, research logic and methodology elaborated in section 4.1, 4.2 and 4.3 respectively. The phases of the study that includes the design of the case study and the deployed methods are highlighted in 4.4 with the quality of research presented in 4.5. The chapter 5.0 is dedicated for the analysis and the results of the research with chapter 6.0 focussing on the innovation statement, key benefits, recommendations, lessons learned, and future work. The chapter 7.0 reviews the objectives of the research with final concluding thoughts of the researcher. The chapter 8.0 is reserved for the bibliography and the appendixes attached in chapter 9.0.

1.2 Rationale of the Research

According to Klappich (2013), in a study conducted by the "Gartner SC group of companies", 80 % of the respondents who were in leading SC roles relayed their main challenges to delivering SC objectives were:

1) Demand Variability and Forecast Accuracy.
2) Difficulties in synchronizing the end-end vale chain processes.
3) Absence of SC visibility.
4) Complexity in SC networks.

Variability is undoubtedly the main challenge in SC efficiency (Cachon 1999). If there is no variability in demand, any SC would function with ease and with very little support from management. However, in reality, variability increases in an ever-growing competitive environment and the more the company manages its variability, they gain a significant competitive advantage over its competitors.

In Figure 2, there are two scenarios that illustrate the challenges that companies face, due to the demand variability.

Scenario 1: If the demand signals have a higher degree of variability, either the set inventory is lower causing a significant probability of shortage to meet the demand.
Scenario 2: The suppliers mitigate this risk by setting a larger inventory buffer to meet the demand of the customer but with added costs that are often shared with the customer making the SC more expensive.

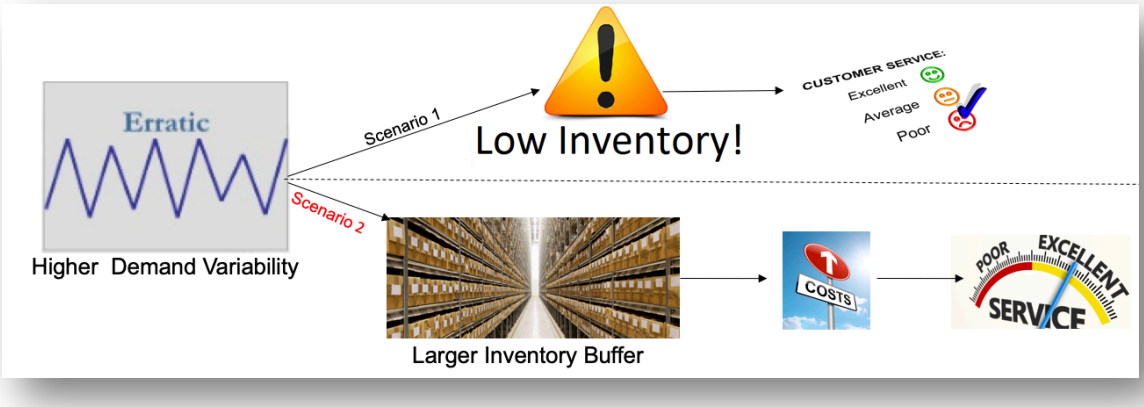

Figure 2: Erratic Demand and its effects on Customer Service Levels (Source: Researcher)

In the case of the smooth demand pattern as illustrated in Figure 3, then inventory levels are kept optimal, that ensures not only lower costs and greater efficiency but also higher customer service levels.

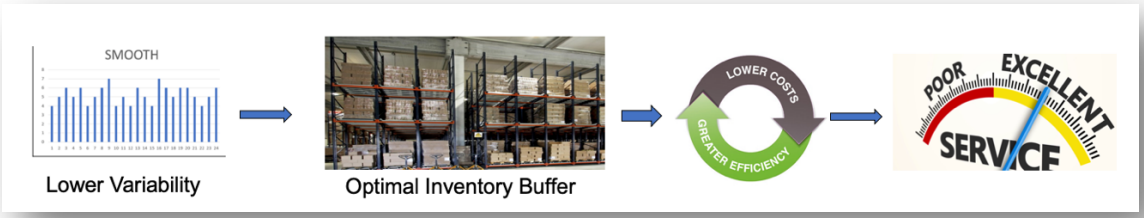

Figure 3: Smooth demand and its effect of higher customer service levels. (Source: Researcher)

As discussed in the earlier part of the paragraph, in order to gain a competitive advantage, the supplier requires a superior planning process that can manage any demand variability on the SC. Planning process is a core function in SCM and establishes key parameters and control techniques that operates a SC (Crimson 2017). The strategic element of any Sales and Operation Planning (S&OP) is managing customer and defining how customer groups are served to ensure that supply capacity is available to meet any demand (New 2010). However, working with

customers in an integrated platform is a key element of the planning process, to identifying and discovering the real customer needs for driving profitable service solutions. An integrated inter-firm planning process between companies can be responsible to provide an accurate demand signal to the rest of the SC, ensuring minimal write-offs and delays in the SC. However, companies decentralize the planning system, citing to difficulties in implementation of an integrated planning process (Lee et al. 1997). The benefits of an integrated planning process approach are cited from academic journals as highlighted in Table 1 based on (Grimson & Pyke 2007; Christopher 2011; Jonsson et al. 2013; Sun 2015). With an integrated inter-firm planning process, visibility of the SC becomes higher allowing the demand fluctuations to be relayed much quicker to the upstream, minimizing the bullwhip effect (Lee et al. 1997).

Table 1: Benefits of an Integrated Planning Process based on Pyke (2007), Christopher (2011), Jonsson et.al (2013) and Sun (2015)

Divisions	Capacities	Target
Customer Relationships	Superior Delivery Performance	Champion Customer
Business Operations	Inventory Turnover and Obsolescence; Capacity Management	Superior SC visibility
Financial Operations	Material Holding costs, Cash Flow	Higher Profit
Personal Development	Training of staff	Addition of vital skills like demand planning

On a decentralized platform, companies often forecast based on historic data leading to disruptions caused by inventory (either too full or too little), minimizing the customer service levels and maximizing the costs of running a higher inventory. Some companies hold inventories, to achieve customer satisfaction levels causing obsolescence, that according to Chopra & Meindl (2016) is the significant reason for increased costs in the SC. Due to different characteristics of businesses, demand pattern differs according to choices of customer preference and functionality of the product. The more the demand variation, the wider the gap becomes in a demand and supply mismatch (Aitken et al. 2003; Dyer & Cho 1998; Kharlamov, Godsell 2015;

Lee 2004; Lovell & Saw 2005). An integrated, inter-firm planning process narrows the gap by offering a tailored supply chain strategy through demand profiling. Despite claims from Pibernik & Sucky (2006), that realization of such an integrated platform where two companies integrate their planning process in to single set of information flow is highly impossible, companies like IKEA, Dell and ZARA have transitioned successfully from a decentralized planning to an integrated planning strategy with in their internal supply chain in the last decade (Christopher 2011). Despite the challenges, collaborative supply chain management approaches are used to highlight the importance of integrated planning (Sun 2015). Similarly supply chain council's operational guide has endorsed the supply chain operations reference model SCOR (Huan, Sheoran & Wang 2004), that uses integrated planning procedures successfully to enhance performance. However, in previous models integrated planning was used among internal business units, the rationale of this research focusses on using segmentation principles in an integrated planning process model between two companies in an end-end value chain that enhances the entire delivery performance.

In order to enhance the delivery performance, it is crucial to reduce the bull-whip effect that are caused often by the upstream suppliers leading to the end-end fluctuation of the demand signals (Lee et al. 1997). In this integrated planning framework, the downstream demand or the end customer demand is passed to the entire value-chain that can facilitate optimal replenishment. As illustrated in Figure 4, in the current state, the supplier's planning process is based on the upstream demand. However, on consideration of the entire demand across the entire value chain of the customer's plants, the bull-whip effect is minimised offering the supplier a reliable forecast mechanism.

The benefits of such an integrated business platform:

1. Customers not only receive the product but "On Time-In full" with a superior delivery performance.
2. Centralized production and resource planning for an enhanced productivity gain across the value chain.
3. Joint ownership of Inventories.

4. LEAN SC
5. Synchronized Business Integration Platform

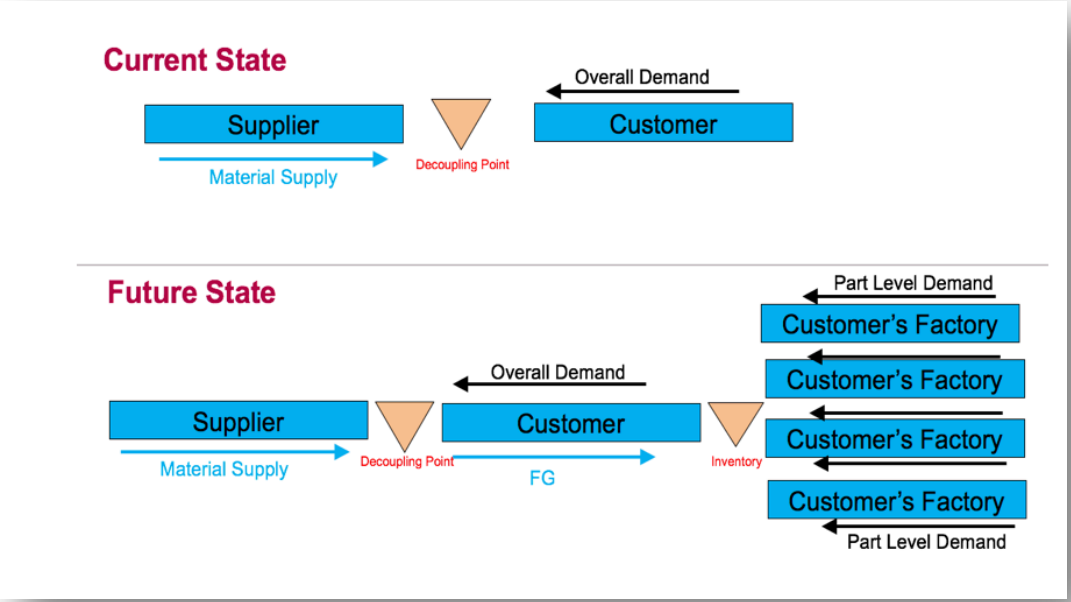

Figure 4: Current Vs Future State Demand Management (Source: Researcher)

In the current state, the upstream demand is forecasted based on historic data while after this research the customers can provide the actual demand based on an actual production plan, facilitating the supplier to retrieve actual consumption of data after analysing the demand profiles of the respective parts. The current and ideal state of the innovation framework is illustrated in Figure 5. An applied innovation framework is detailed in Chapter 3.

Summarising this chapter, this research will benefit the entire value chain in:

1) Enhancing Supplier Performance.
2) Connecting of inbound flows to actual manufacturing
3) Aligning of supply strategies
4) Seamless production (no stoppage due to material availability).
5) Minimising bull-whip effect due to synchronization of upstream with downstream demand.

6) Automatic Replenishment of Inventory.

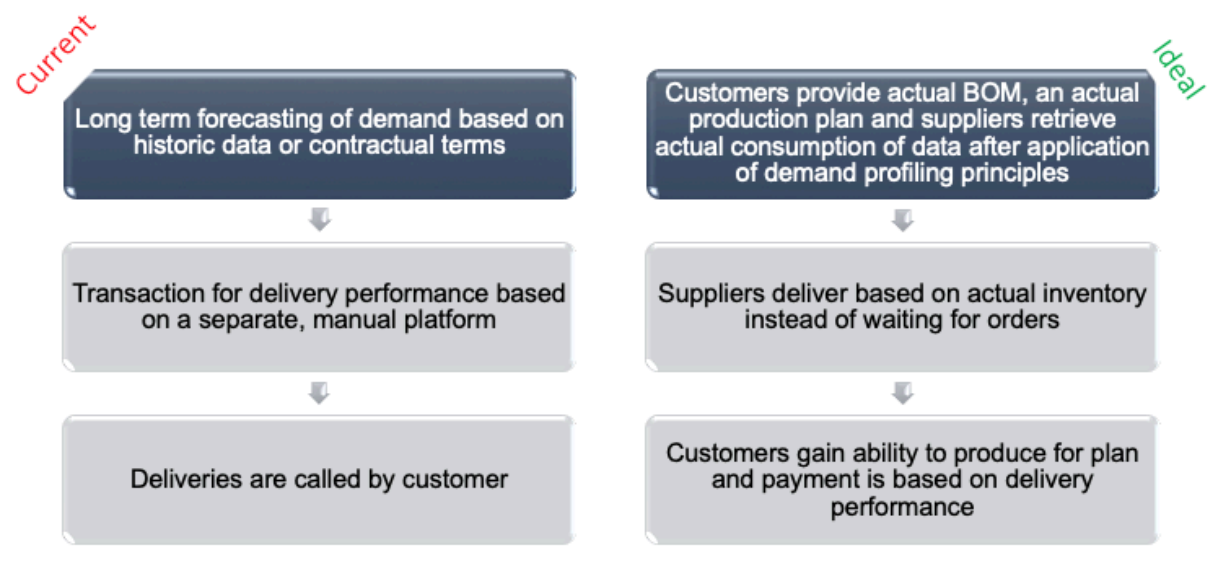

Figure 5: Current Vs Future benefits.

1.3 Research Aim and Objectives

With this rationale, the aim of the research is:

"To explore the opportunity to improve inter-firm productivity through the application of demand profiling"

The direct benefits achieved through this research will be improved productivity of the automotive steel supply chain between JLR pressed parts situated at Halewood UK and TATA Steel UK through the implementation of an integrated planning process.

This will enable the delivery of improved customer service at lower supply chain cost, between:

- JLR Halewood and JLR final assembly sites
- Tata Steel and JLR Halewood

This aim is to be achieved by:

- **Examining** the current stage of planning process, delivery strategies, performance levels and studying the demand, supply and inventory process. (A1)
- **Developing** inventory models that highlights potential business benefits for the companies involved based on demand profiling (A2)
- **Investigating** the structure and processes within and between firms that affect the business performance by performing an Enabler and Inhibitor Analysis (A3)
- **Assessing** planning and collaboration issues through a maturity assessment tool (A4)
- **Proposing** a pragmatic future state design in the form of a big picture map enabling the companies to exercise better planning procedures (A5)

Goal of Research: *To enhance Productivity in an end to end value chain*
Research Setting: *UK Automobile Manufacturing Companies*
Research Method: *Qualitative/ Quantitative*
Approach: *Case Studies / Historical Data*

The portfolio of submissions performed during this research has allowed the researcher to addressing these areas in a logical structure. The structure of the work conducted during the entire course of this research will be highlighted in section 1.5.

1.4 Research Value and Scope

The research investigates planning capabilities using segmentation principles not within a single company but with two different companies and their entire downstream processes involved in a single SC, which is novel in supply chain segmentation. The forecasting accuracy between the companies is a vital component and this research explores beyond that and explores an integrated planning hub, that will enable higher SC visibility by mapping the entire internal demand of the customer that eliminate information delays and enhance forecasting accuracy between the companies. This research will combine three different SC segmentation methods and profile demand

based on: ABC (Pareto based), IDM (Intermittent Demand Management) and DD (Demand Decomposition). The research intends to provide quantifiable benefits in providing an optimal material availability platform with sufficient inventory buffer to the companies involved and capture the performance of the entire SC. Furthermore, the focus in combining inter-firm demand management and integrated inventory management is novel to supply chain segmentation methods and all efforts are taken during the course of the research to optimise inventory and foster new collaboration techniques that help to achieving first-class service levels.

Furthermore, the scope of this research is modelled on automotive steel supply chain, but the principles could then be rolled out by:

- JLR to all suppliers
- Tata Steel to all customers

1.5 Structure of Submissions

This engineering doctorate study was structured to follow the progress based on portfolio submissions and MSc / DTC module participation and assessment. The researcher has documented this separately in the “Personal Profile” submission. As highlighted in Figure 6, in the initial phase the researcher used secondary data sources like peer reviewed journal publications, industrial reports, policy documents, books and internet to define and design the fundamental theory and concepts required to perform the research.

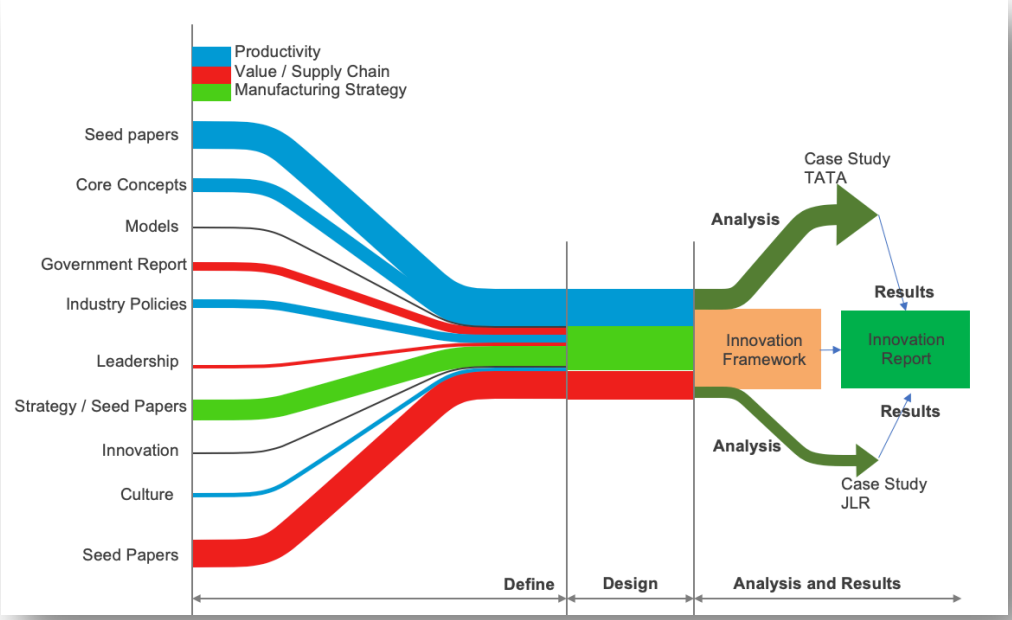

Figure 6: Portfolio Approach

The **First Submission** was a detailed literature review in **Manufacturing Strategy**. In this submission, the researcher focusses on the changing manufacturing landscape with emphasis in the product and process development from the 1960's. In the course of this study the manufacturing strategy in correlation to manufacturing and productivity. A list of competitive priorities was identified along with the competitive advantages aligned to today's business needs.

The **Second Submission "Productivity"** was in a form of report that explained about the core definitions of productivity, profitability, performance, effectiveness and efficiency. Summarising the submission, why productivity is an important topic for UK manufacturing was discussed with key drivers identified for enhancing productivity.

The **Third Submission "Supply and Value Chain"** focused on Supply and Value chain with information on SC management and integration issues including the bullwhip effect. The value chain perspective was highlighted with examples of primary and support activities in addition to using LEAN principles in SC planning.

The **Fourth Submission "Innovation Model"** primarily focuses on single and inter-firm planning processes, the barriers in inter-firm planning and various inventory policies are further elaborated. The focus then shifts to segmentation principles, and the rationale of using demand profiling for this research. Towards the end of this

submission, an Innovation model is presented with orient towards a multi-firm SC segmentation strategy.

The **Fifth Submission "Personal Profile"** depicts the foundation of the Engineering Doctorate Program explaining the researcher's personal and academic competences and the expertise gained through this research and the MSc modules undertaken. A detailed summary is presented in this report.

The Final and Sixth Submission "Innovation Report" addresses all the issues of methodology, research approach, case studies undertaken, and the key findings achieved during this course of the research with all the business benefits and contribution to innovation.

The details of portfolio submission are presented in Table 2.

Table 2: Portfolio Submission Structure

Number	Portfolio Title	Scope of Submission
1	Manufacturing Strategy	Literature Review
2	Productivity	Lit Review / Industrial Analysis
3	Supply and Value Chain	Lit Review
4	Innovation Model	Lit Review / Define and Design
5	Personal Profile	Competencies
6	Innovation Report	Case Studies/ Analysis/ Validation / Business Benefits

1.6 Summary of the Introduction Chapter

In summarising the introduction chapter, the rationale of the research was discussed with the research aims and objectives listed in section 1.3. The insights that explain the value and scope of performing such a research is explained in this chapter with the order and scope of the submissions discussed in the end of this chapter with details of the individual submissions. Overall, the chapter revealed the importance of managing demand variability and the need of an integrated planning process in an end-end value chain between two companies to solve the demand-supply mismatch.

2 Industrial Context

"For me context is the key – from that comes the understanding of everything"

Kenneth Noland 1924 -2010

The aim of the engineering doctorate program is to study on real-world industrial challenges in SCM and furnish contribution to innovation by research and analysis. This study will focus on the automotive industrial partners which took part in this study. The OEM (JLR) and its steel supplier (TATA Steel) will be presented along with their core businesses, collaboration practices, organisation structures and their orientation towards a demand driven environment, in an end-end value chain planning exercise. A short description of the automotive supply chain will be presented in section 2.2, with the need of an integrated planning process. The chapter outline is listed in Figure 7.

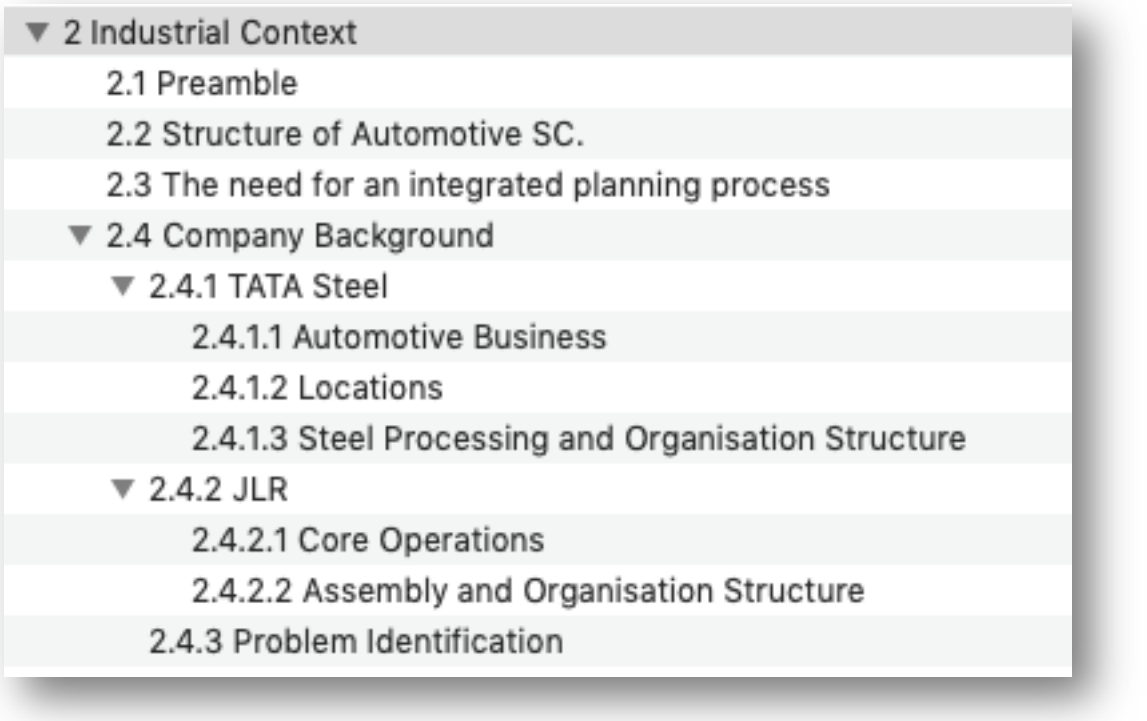

Figure 7: Outline of the chapter Industrial Context

2.1 Preamble

Intense competition, global market fluctuation along with an ever demanding customer advocates the stronger need of an efficient supply chain to gain competitive advantage

within the industry (Cao & Zhang 2011). The companies like Toyota still find it challenging to deal with its suppliers despite introducing principles of JIT inventory and lean manufacturing (Ambe & Badenhorst-Weiss 2011). As discussed in the introduction chapter of this research, companies that manage demand variability and show flexibility and responsiveness to the demand variability of the customers are likely to succeed (Binder et al. 2008). The broader practices of SCM shifted towards LEAN management to enhance SC productivity, that eventually reduces costs and increases performance (Cox 1999). The management concepts like JIT, reducing distribution facilities and enhanced analytics were introduced to improve SC performance (Ramanathan 2014). However, the ever-changing customer demands require the supply chain to be LEAN and having attributes of flexibility and responsiveness from its downstream operations (Cox 2007). The automotive industry in the last decades have experienced a transformational evolution (Swiecki & Gerth 2008). From a traditional "PUSH" system, where the market demand was forecasted and fed to manufacturing, the industry is approaching towards a system that is demand driven-production approach (Zhang & Chen 2006; Ambe & Badenhorst-Weiss 2011). The automobile industry, however is set up in a traditional background where mass production is the core strategy and this strategy relies in the ability of the company to forecasting demand, as accurately as possible. This demand then is used to create a production plan in an existing configuration, manufacturing products in stockpiles. In order to avoid the stockpiles, there is a need to develop a demand driven model that manufactures products for customer orders based on actual demand.

2.2 Specific Context of TATA – JLR Collaboration

In the scoping phase of the study, TATA and JLR placed high importance in minimising reactionary management techniques to solve ad-hoc issues in S&OP management. The preliminary suggestion was incorporating a management dashboard that facilitates the management to make decisions based on their supply chain visibility. The supply chain manager in both these companies emphasised that they supply chain visibility was a main challenge and the demand variability was an outcome of poor visibility across the end-end value chain. However, in order to understand the entire supply and demand management process, it was essential to study the entire

steel making process, the information flows and the S&OP parameters. It was also essential to identify the demand management principles within JLR's plants. To cover the entire spectrum of supply and demand management within and between two companies, the underlined approach was used:

1) Qualitative study that can depict the entire big-picture map of the S&OP processes of the two companies
2) A maturity assessment tool enabling the concerned business unit to measure the individual strength and weakness
3) Study the implications that affect business performance
4) Qualitative analysis on demand variation

By adopting this approach, this research facilitates the business units of these two companies evaluate their supply chain based on the qualitative and quantitative information.

2.3 Structure of Automotive SC.

Automotive Industry has one of the most complex processes, when linked together form a SC from the various tiers of suppliers to the end customer (Sturgeon et al. 2008). The basic structure of the automotive SC consists of:

1) Physical Flow
2) Information Flow
3) Strategy

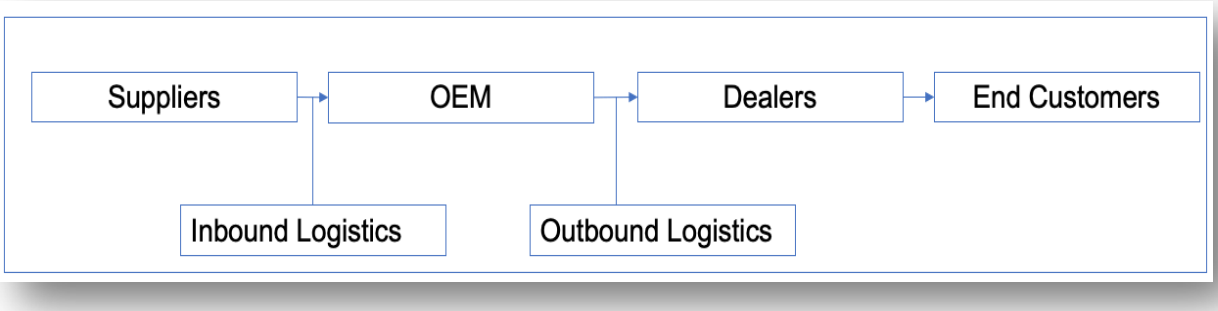

Figure 8: Physical Flow of an Automotive SC

The **Physical Flow** is illustrated in Figure 8 which highlights the information related to the movement of physical goods in transit or hold within a SC (Iyer et al. 2009). The parts produced by the suppliers are transported by the in-bound logistics to the assembly shop. At the customer's assembly plant, the vehicle passes to the body shop, then moves to paint shop before going in to the final assembly as shown in Figure 9. In regard to this research, a detailed illustration of the entire physical and information flow including the decoupling points of the JLR-TATA supply chain is presented in chapter 5.1.1.4

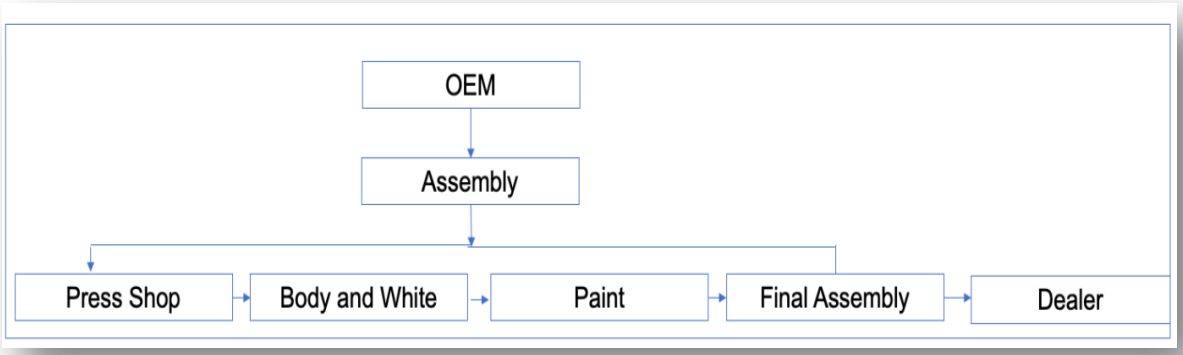

Figure 9: Assembly plant

The **Information Flow** is where planning processes synchronise and integrate with physical flow, ensuring the physical flow is operated productively (Iyer et al. 2009). The main tasks are to fulfil demand in time, minimise inventory and plan production for optimal use of materials.

The **Strategy** is defined in relation to the needs of the customer and the competitor's proposal to meet the service levels. In this particular industry, there are often two production strategies namely demand driven and forecast driven (Zhang & Chen 2006). In the demand driven model, the production strategy is based on definite orders from customer while in the forecast driven model, the customer requirements are considered during the order process and products are build based on forecast.

In this context of research, the supplier TATA steel works on a forecast-driven production strategy where orders in pipeline from JLR are amended to its requirements for an MTS or BTF system.

2.4 The need for an integrated planning process

It is essential for companies to shift to a process focused structure in an integrated planning system (Christopher 2011). To create a process focused structure, different restructuring plans must be taken in to account, such as Postponement Strategy. Christopher (2011, p.177) augments that one of the main strategies of implementing inter-firm planning is by postponement or delayed configuration. This concept can derive benefits by sequencing the events and delaying the configuration as far as possible (Yang, Yang and Wijngaard 2005). As illustrated in Figure 10, the decoupling point, highlights the inventory buffer, where demand driven and forecast driven planning can be separated (Childerhouse & Towill 2000; Childerhouse & Towill 2003). As companies extend production and distribution in a wider context, the logistic lead time differs. However, postponement opportunities can be identified by the measure of the lead time and configurations can be delayed, if the lead time is short or prioritized or if it is longer. Postponement also facilitates modularization (Christopher 2011), allowing products to be designed using common parts or sub-assemblies to facilitate customization. If the product is obsolete, some of the parts can be used by other products, reducing the complexity of the production and significantly improving the productivity (Sun 2015).

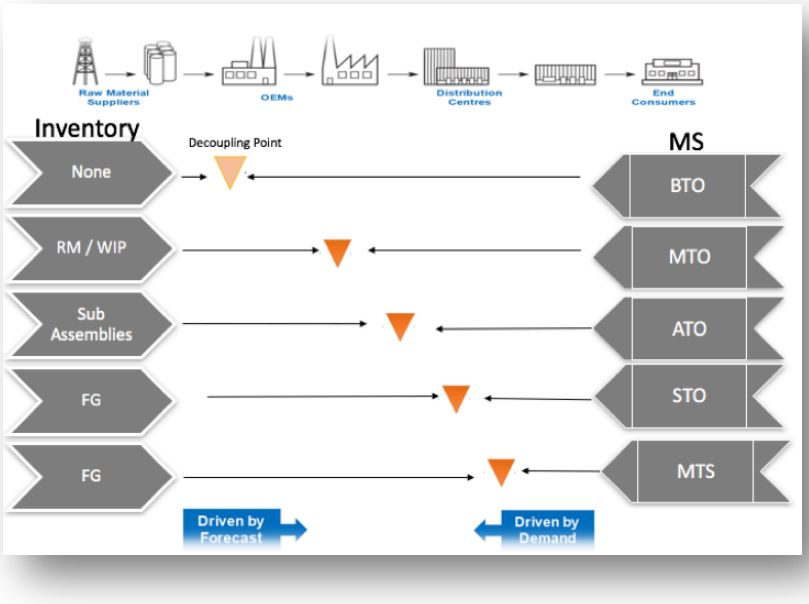

Figure 10: Postponement Strategy adapted from Childerhouse & Towill (2011) and Christopher (2011)

The location and form of the inventory can determine the manufacturing strategy that can be classified in to different types (Sun 2015):

- BTO (Build to Order): In this context, the OEM is involved only in the buying activity after receiving the orders from the customers and holds no inventory. This causes a longer lead time but can cope with any demand variation. This particular manufacturing strategy is apt for products that are unique in nature and where the consumption of such products is rare.
- MTO (Make to Order): In this particular strategy, the OEM's start production when the order arrives. This must be supported with holding inventory in the form of raw materials or the work in progress state. This strategy is similar to BTO where there is no requirement to store FG in inventory.
- ATO (Assemble to order) The OEM's for its own production store sub-assemblies and wait for potential customer orders. The final assembly starts immediately once the order arrives and a shorter lead time is guaranteed.
- STO and MTS: They both correspond to Finished Goods with the difference being the location where the inventory is on hold. For MTS, the inventory is held locally, regardless of the arrival of demand. Whereas, in the STO context, the inventory is hold in a central warehouse, ready to be shipped on arrival of the demand signal. However, STO and MTO models are dependent of a higher level of forecast accuracy to minimize over and under stocks (Mason-Jones et al. 2000).

The productivity of the SC depends on the type of the inventory the company holds. There are necessary trade-offs that companies focus, for an efficient business operation. The value of the inventory can be increased along with the increase in product availability and market responsiveness by moving from keeping RM's to FG's (Sun 2015). In a contrasting scenario, when moving FG's to RM's, the value of the inventory decreases along with the ability to respond to market but provide companies higher flexibility. Hence, it is vital for companies to jointly collaborate in determining the manufacturing strategies and the holding of respective inventories to enhance inter-firm productivity. Taken in to consideration all the above models, this research will develop a model that will emerge in chapter 3.1. The model will be based on

demand profiling that facilitate companies to organize their manufacturing strategies according to the real demand signals, delivering not only reductions in inventory but improving on Time – in Full (OTIF) delivery management.

2.5 Company Background

2.5.1 TATA Steel

The TATA group consist over 100 companies that operate across six continents (TATA 2017). The group was founded in 1868 by "Jamshed Tata" in India. The current group of organisations range from defence, financial services, consumer goods, infrastructure and manufacturing. Within the TATA group, TATA Steel was founded in 1907 and stays as an engine for global investments in the entire steel industry. The whole group employs over 695000 employees with over £100bn revenue. The TATA Steel group employees over 21000 employees, with over £1.7bn revenue. In October 2006, TATA Steel acquired the company CORUS and rebranded as TATA Steel Europe and in September 2017, TATA has announced to merge its steel business with German Steel company "ThyssenKrupp", forming a joint venture named "ThyssenKrupp Tata Steel". The headquarters will be in Amsterdam (TATA 2017). Currently, TATA Steel has two integrated steelmaking sites in Port Talbot, in Wales and Ijmuiden, Netherlands, in addition to several small sites spread across Europe. The main products of TS Europe range from rolled flat steel trough for cladding that caters for several industries from packaging to automotive. In order to limit the scope, this research study will focus on the automotive steel products supplied to Jaguar Land Rover (JLR).

2.5.1.1 Automotive Business

The automotive industry in United Kingdom recovered steadily since the financial crisis in 2009, where production fell by over 40 % (Name & Banks 2014). However, the automotive manufacturing still faces numerous challenges regarding supplier bases and production capacity, due to UK's exit from the European Union (TATA 2017). TATA steel's core strategy focuses on automobile industry within the UK and has already built a portfolio of automobile customers namely BMW, GM, Honda, Nissan,

Reno and JLR. However, TATA steel is keen to increase the automotive portfolio, especially with JLR. Some of the key business aspects of the automotive business are listed below (TATA 2017):

- TATA Steel UK produces around 75000 tonnes steel every week.
- For automotive specs, it produces mostly coils and pressed blanks which weigh from 12-30 tonnes and six foot tall and wide.
- TATA Steel's products cater to a variety of industries including infrastructure, packaging, defence and automobile.
- TATA Steel supplies 50% of UK car makers steel requirements.
- 25% of revenue are from Automobile industry

The sectors and products of TATA steel with the sales value is summarised in Table 3.

Table 3: Sectors and Products of TATA Steel

Sector	Main Products	% Sales
Construction / Transport/ Packaging	Steel Bars, Concretes,	60%
Engineering Business	Radiators and Drums	15%
Automotive	Blanks, Coils, slit coils, press blanks	25 %

2.5.1.2 Locations

TATA Steel UK is one of the major suppliers for the automotive sectors both in UK and Europe. It has two main sites in the UK with dedicated distribution facilities for automotive sector as shown in Figure 11. In section 2.4.2.1 a detailed presentation on JLR's perspective will be underlined.

Figure 11: TATA Steel's Automotive Sites (Source: TATA, 2017)

2.5.1.3 Steel Processing and Organisation Structure

TATA Steel covers various process stages in steel production. As illustrated in Figure 12, from the supply base, the iron ore is placed in a blast furnace in order to transform the core in liquid iron. The BOS (Basic Oxygen Steelmaking) is a process where carbon blended pig-iron is made in to steel. In the next phase, steel is casted as slabs. The slabs are transported to the entry end of the reheat furnaces. After exiting the furnaces, the slabs thickness is adjusted, and other product specific measurements are configured. Before passing the finishing mill, it is coiled on down-coilers with maximum weight of 34 tonnes. The hot rolls are then processed at the link mill BOS to remove any oxidation during the rolling process.

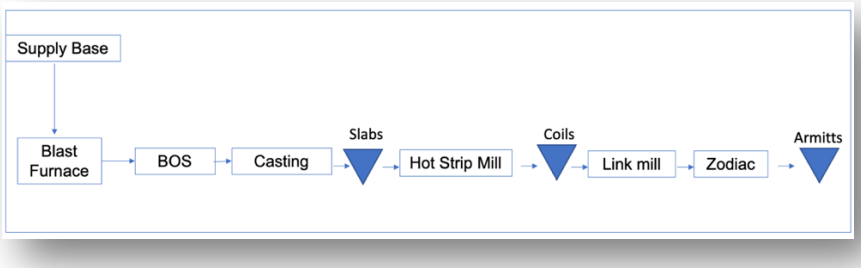

Figure 12: Physical Flow of Steel Production Process at TATA Steel (Source adapted from WMG))

The final finishing operations like oiling or cutting are undertaken at the link mill. The grid point is where the automotive specs are separated and allocated for specific customers. For JLR, around 100-120K tonnes of slabs are allocated and after the hot mill, 12000 Tonnes of coils are allocated. With a rail rink, the slabs and coils are transported to the galvanizing plant “ZODIAC” where the coil is given a zinc coat to improve surface quality and other metallurgical qualities. The coils are unwound, and gauge checked prior to welding forming a continuous strip. The inventory at this point is around 7-10 days of stock before the end delivery to JLR’s warehouse Armitts. A detailed presentation of the decoupling points including “Armitts” is addressed in section 5.1.1.4.1. The information flow is organised at the Llanwern plant and is presented in Figure 13. A dedicated SC director overlooks the automotive sector at TATA Steel. The order fulfilment and in time delivery team (OFID) heads the operations with a dedicated customer service team overlooking JLR’s orders. At receipt of order, the information is processed by the demand management team which in turn transforms the demand, in to production plan with the support of the scheduling team. The automotive replenishment team takes the entire responsibility of the replenishment of the orders.

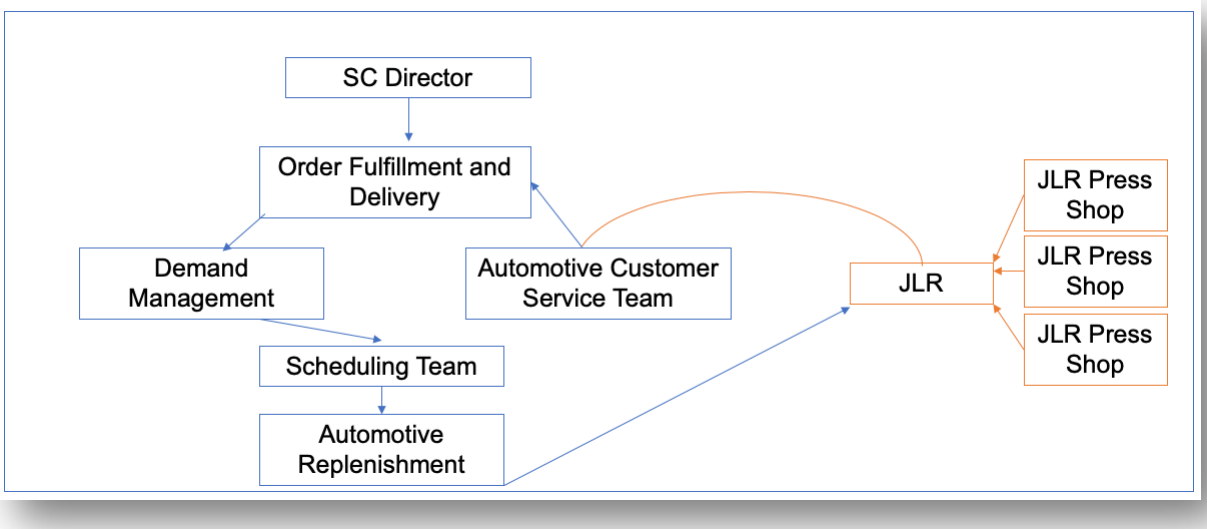

Figure 13: TATA Steel’s Demand Management Structure for customer JL

2.5.2 JLR

Jaguar Land Rover PLC is a holding company of JLR Limited that is head quartered in Coventry, UK and a subsidiary of "Indian Automotive Company" TATA Motors Limited (JLR 2017). JLR limited designs, develops and manufactures vehicle bearing Jaguar and Land Rover trademarks as Jaguar and Land river merged as one single company in 1968, then a subsidiary of BMW. In 2000, Ford acquired Land rover up until 2008, when TATA motors acquired Jaguar Cars Limited and Land Rover (JLR, 2017). The total revenue of JLR amounts to over £25 billion with a net income of over £1.1billion. It employs over 43000 people across UK, China, India and Brazil. It is also the UK's largest automotive customer employing over 23,000 people.

2.5.2.1 Core Operations

There are 11 main facilities for JLR to undergo manufacturing, vehicle assembly and R&D activities, of which eight are located in UK, one in India, one in Brazil and one in China. In Table 4, a short description is provided on the type of the facilities and the locations (JLR 2017).

Table 4: Core Operations

Facility	Location	Function
R&D	Gaydon, UK	Vehicle Design, Development and Testing
R&D	Whitley, UK	Engineering and Development
R&D	Warwick, UK	National Innovation Centre
Assembly	Castle Bromwich, UK	Assembly plant for models XF, XJ and F
Assembly	Halewood, UK	Assembly for models Land Rover Discovery Sport, Range Rover Evoque
Assembly	Solihull, UK	Assembly for models Range Rover, Range Rover Velar, Land Rover Discovery and F pace
Assembly	Pune, India	Assembly plant for complete knock-down kits
Assembly	Changsu, China	Assembly for models XE and XF
Assembly	Itatiaia, Brazil	Assembly for models Range Evoque
Special Vehicle Operations Development	Ryton-on-Dunsmore, UK	Special Vehicle Development
Engine Assembly Plants	Wolverhampton, UK,	Engine Assembly Plants

In this scope of research, the project is focussed on the “Halewood Body and Assembly Plant.” The JLR Halewood plants work in total with six suppliers of steel including TATA Steel. According to the supplier relationship index, JLR offers the best potential of any OEM to its suppliers for keeping agreements in price and protecting the intellectual property of the supplier (JLR 2017).

2.5.2.2 Assembly and Organisation Structure

As mentioned in the previous chapter, Armitts is the main warehouse of FG for the JLR Halewood assembly plant. Most of the TATA Steel’s supply of coils and blanks are stored at Armitts. The Halewood plant operates in a pull system of replenishment and based on the pulled stocks, the invoice is generated to the supplier. There is a daily delivery system on place that operates from 6AM - 10 AM and 6PM - 10 PM. After the stocks are pulled, it is placed in a holding area called the “The Tent” closer to the Assembly plants. In the “Tent”, 3-4 days of stocks are stored. The quality inspection takes places inside the tent and on any issues with respect to qualities, the product is sent back to Armitts. The next round of movement is towards the blanking which is batched in sizes of 1500-1700. The coil batches are based on the frequency of requirements and each batch is made every eight days due to significant changing over and fitting times. The pressing is taken care by 10 press machines, generating over 140-150 JLR vehicle parts made by TATA steel’s products. The pressed parts are then transported to the Halewood assembly plant where stocks are kept for in between a maximum duration of four days and minimum duration of two days. The final parts are then dispatched either to the “Body and White” shops at JLR or to other plants of JLR, which produces similar vehicle models. The entire lead time for one complete batch is 1-2 weeks. The process is presented in Figure 14.

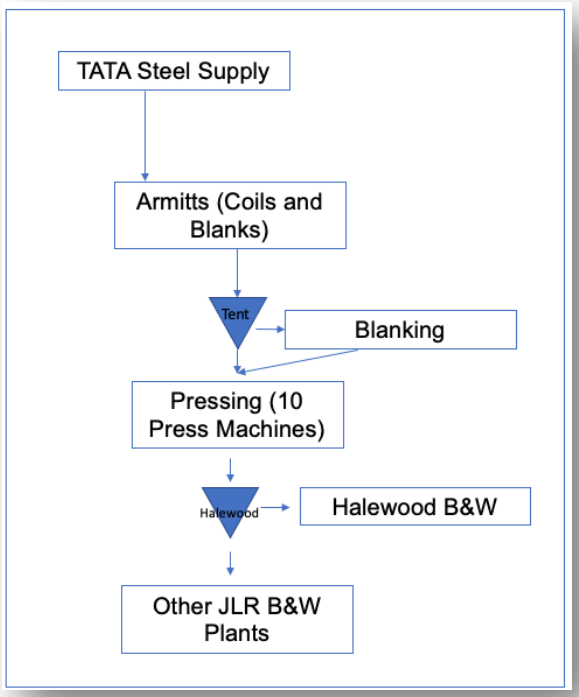

Figure 14: Physical Flow of Supply at Halewood

The organisation structure at JLR consists of a planning manager who overlooks the entire supply process. There are six suppliers of steel and the planning team works in tandem with all its suppliers including TATA Steel. The production planning and control team calculates actual requirements in a 4-week rolling window and sets the material requirement matrix that is based on capacity. The MRP team operationalises the entire product portfolio in terms of the numbers of cars produced per year and generates a six-month demand requirement window with inputs from the B&W team and Trim &Final team. The MRP is run on a CMMS system that sets safety stocks, set batch sizes and set production requirements. The CMMS system is visible to TATA's customer service team where a daily review is taking place. The process is presented in Figure 15.

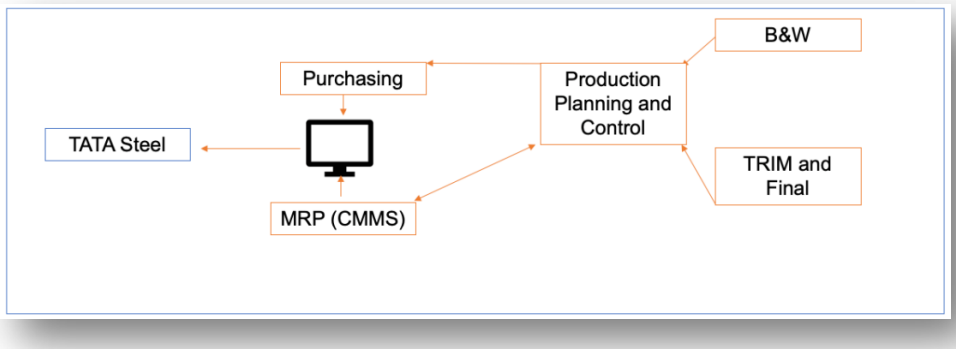

Figure 15: Order Generation Structure for TATA Steel

Summarising this section, a detail perspective of the companies was listed with its automobile business and its core collaboration with JLR was highlighted. More details on the order management and sale and operations planning processes will be in chapter 5. With insights that were gathered during the field visits. Additional information will be provided in chapter 5 of this report on the demand management, segmentation principles and a big picture map listing the entire physical and information flow in section 5.1.1.4.

2.5.3 Problem Identification

TATA and JLR's operation are connected in complex value chain involving different stake holders, internally and externally. It is vital for the researcher to identify the key problems both the companies face in managerial, organisational, supply and demand contexts to formulate a research design that potentially addresses them for potential benefits. The challenges that are to be identified are listed below:

1. As discussed earlier in the section, there are collaboration measures in place between the two companies like the order management, demand management and S&OP principles. However, it is essential to find out, if such collaboration is of reactionary nature? and if there is any formal process in place like supplier liability agreements and work flow management systems.
2. In the area of S&OP planning, TATA uses advanced analytics modelling for capacity planning. However, a deeper insight on these analytics will pave through in reflecting policies and procedures that is implemented in the end-

end demand management. On the other side, it is also important to study the JLR perspective of analytics in demand planning and yield management.

3. In a complex network of production, several MRP and ERP solutions are used by both the companies to address factory planning, production capacity, material requirement and demand management. It is crucial to study the significance of these systems and provide recommendations If necessary, for optimisation.
4. On the front of demand forecasting, it is essential to investigate the internal constraints and the hand off points to find, if any amplification of demands is caused at the hand off points or in the process of internal demand transformation. In addition, it is of importance for this study to understand the end-end forecasting methods used by these two companies (from the vehicle build team to the slab grid point of the steel supply).
5. In the field of inventory management, right sizing the inventory along with analysis of buffering strategy must be studied to evaluate the variation of demand and its effect on Inventory.

2.6 Summary of the Chapter

In this chapter, the organisational structure was studied along with the core operations of the individual companies. The need of an integrated planning was analysed based on literature that facilitates to develop an innovation framework. The core problems the companies face in an end-end value chain are listed towards the end of this chapter.

3 Innovation Framework

"There is no Innovation and creativity without failure. Period"

Brene Brown

In the fourth portfolio submission "Innovation Framework", the rationale of using a demand profiling was discussed along with an Innovation framework developed underpinning the segmentation principles. In section 3.1, a short description is provided in this Innovation Framework chapter, highlighting the concept of integrated planning and supply chain segmentation. The outline of this chapter is presented in Figure 16

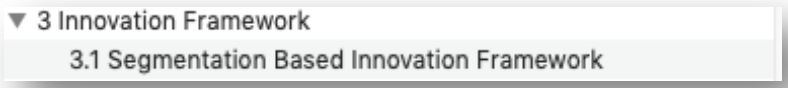

Figure 16: Outline of the chapter Innovation Framework

3.1 Segmentation Based Innovation Framework

The demand management is dealt with an historic set of data available with the supplier. In most of the cases, it does not represent the actual consumption of the data. In contrast, the companies just uses the historic data to forecast production and inventory management accumulated for a period of time termed as the "The Burbidge Effect" (Burbidge 1991). However firms individually feed volume-variability data acquired from historic analysis in regular intervals, that increases the variability in the upstream and leading to forecast which does not correspond to actual demand (Lee et al. 1997; Simchi-levi et al. 2013). In addition to that, the companies restrict frequent ordering due to the costs and management involved and often try to delay or batch order. The periodic ordering causes a bull whip effect due to the irregularity of orders amplifying the variability due to the demand surge in the upstream. The implications caused due to this amplification of variability is often felt at the shop floor (Disney & Towill 2003). As illustrated in Figure 17, in today's state, the demand planning from all SKUs are treated no different from the high volume, higher value SKUs. In addition, the central demand is on a factory level with little or no visibility beyond the purchasing department of the factory. In an ideal proposed state, it is suggested to consider the

demand from the various plants linked with the factory and placing a single, central planning hub, that differentiates only the holding of inventory. The end-end demand data is processed in the central hub to facilitate production planning process. In the ideal state, the demand is segmented in to various categories such as (Wedgwood 2006):

1. Smooth = Demand is stable
2. Intermittent = Demand is infrequent for a constant quantity of products
3. Erratic = Demand Is frequent for high variable quantity of products
4. Lumpy: Demand is not frequent with high variable

Additionally, it is regarded as a combination of demand profile such as stable periodic variable and a volume throughput such as Runner, Repeater and Stranger.

Runner

This strategy is applied for high value, fast moving SKUs. The companies are recommended to make to stock by issuing repeat orders on a FOC (weekly) and a FOQ that can assure stable supply and availability of products in the central hub. All the SKUs in this category are likely to act as high value products for the companies, providing higher monetary benefits.

Repeater

In this category, the demand is more variable with the volume of orders in comparison to the runners. As forecast accuracy becomes challenging, a combination of manual forecasting is required with the statistical forecast at the ROP. The cycle of ordering will vary but have a set periodicity with the quantity being fixed. In order to meet the customer demands on this category of SKUs setting safety stocks levels that are bit higher than the Runner is expected to tackle the variability in demand.

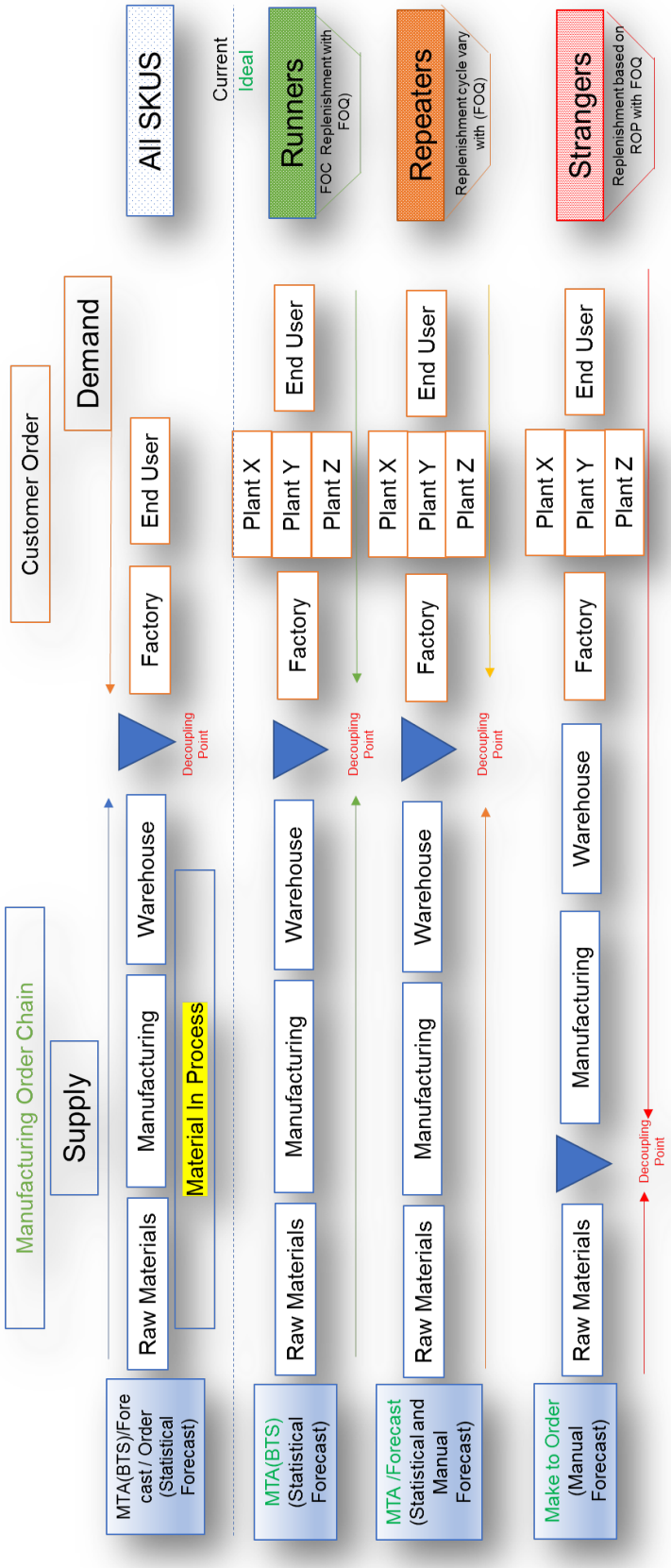

Figure 17: Innovation Framework based on Segmentation

Table 5: Inventory Policies

Segment	Runner	Repeater	Stranger
Inventory Policy	MTA/MTF	MTA/MTF	MTO
Forecast	Statistical	Manual & Statistical	Manual
Order Strategy	Automatic order at ROP	Review at ROP	Case by Case
Review	Weekly	Monthly	Quarterly
Buffer Stock Levels	Medium	Medium	No Stock
KPI	Maintain Delivery Performance and Volume	Manage risk	Manage risk

Stranger

This category is dedicated for slow moving products. A case-case analysis is required, and companies are advised not to stock products, falling in this category. There is no fixed periodicity, but quantity will be fixed based on the ROP in comparison with the other stocks in terms of volume, reducing stocks in this MTO strategy will reduce significant costs. The details for the above-mentioned categories and their respective inventory policies are listed in Table 5. In all cases, the aim is to replenish to the buffer and he minimum inventory required will be determined based on the demand variability and the replenishment lead-time.

3.2 Summary of the Chapter

In summarising this chapter, it is evident that a “one-size-fits-all” strategy cannot be applied in all contexts of supply chains. The segmentation principles of the SC can significantly mitigate risks to prioritising with the wrong product. The sourcing policies are flexible and the applied segmentation principles allow the suppliers to concentrate on the product portfolio’s adding a competitive advantage in establishing higher service levels.

4 Research Methodology

"Design is not just what it looks like and feel like. Design is how it works"

Steve Jobs (1955 -2011)

To make a relevant contribution to innovation, it was crucial to develop an effective research design that can identify the core principles, whilst addressing the gaps. The researcher has an engineering and management background that suits the concept of design science and as the aim was to improving productivity in a multi-firm collaborative context, the key output was to set principles that could help solution architects and application managers. During the initial phase of this study, the researcher participated in four philosophical modules that paved way to a deeper understanding of how theory and practice can be addressed in a management research context, in addition to fitting the wider philosophical debate in a research design. Management research is already a complex architecture of people and organisations (Godsell 2008) and adding the complexity in this work was the engineering context of the participated industries. Despite the companies in this study come from a same family of business, they lacked over-all understanding of mutual collaboration principles. This research design was the most critical aspect of this study as it was supposed to provide insights of the entire process management flow with managerial interventions from two separate companies working in a single business context from an unbiased view. The main work for this chapter was based on the work of (Yin 2009; Godsell 2008; Saunders et al. 2009). In this chapter, there are three key areas the researcher undertook to designing the research:

1) Research Philosophy
2) Designing the study
3) Ensuring the Rigour of the Research Design

The section 4.1 seeks to explain the importance of ontology, epistemology and methodology in correlation to the researcher's core personal belief and the rationale for the chosen methodology. The section 4.2 highlights the process in which the research was conducted with data sources, analysis and dissemination. The section

4.3 summarises the chapter with the four design tests performed to ensure the rigour the research design and the ethical implications. The outline of this chapter is illustrated in Figure 18.

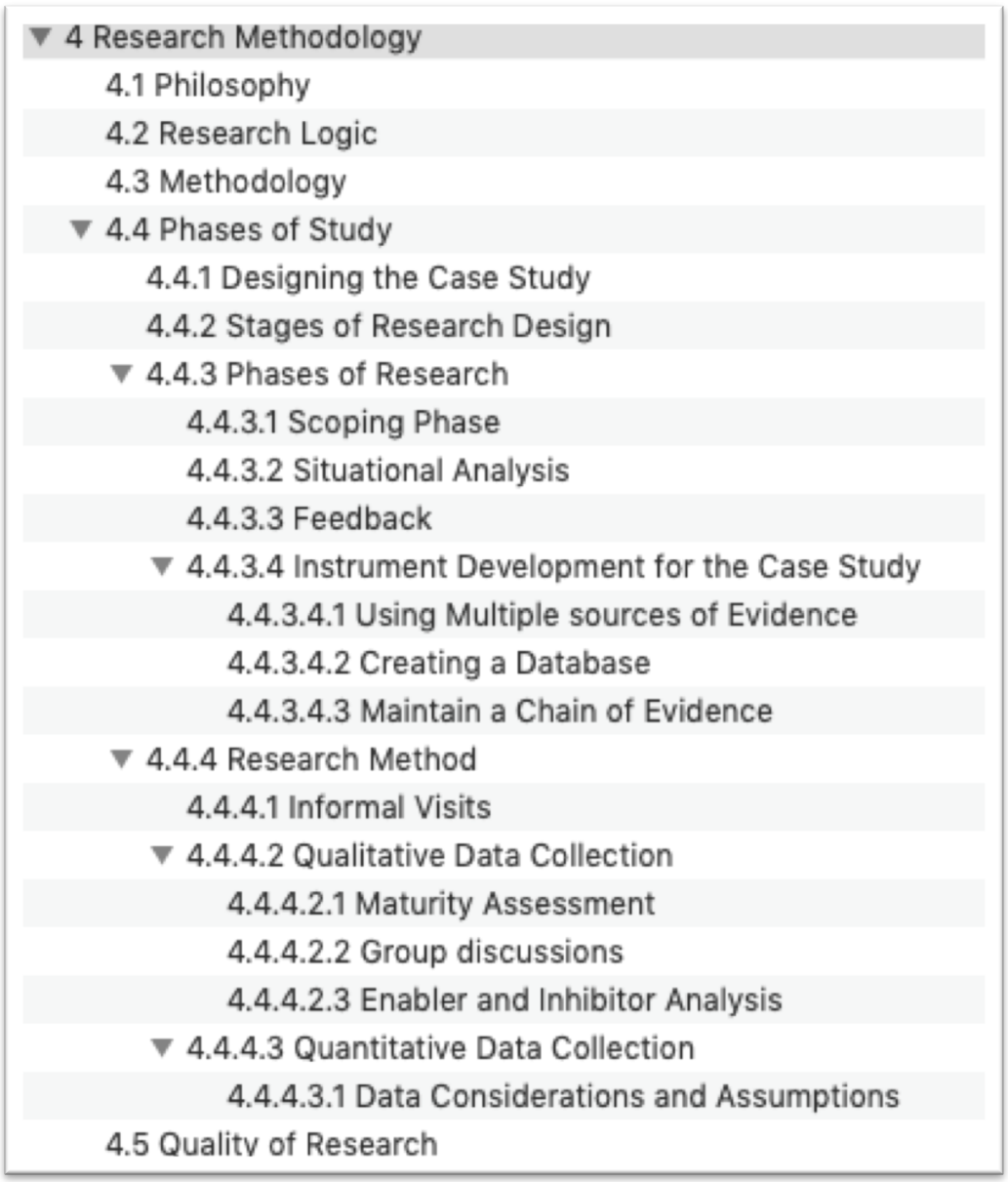

Figure 18: Outline of the chapter Research Methodology

4.1 Philosophy

"Philosophy begins with wonder"

Plato (427-347 BC)

The two main elements that need to be aligned in philosophy are metaphysics and epistemology (Godsell 2008). Metaphysics is more in relation to knowing the questions of being and the assumptions made about the nature of reality is termed to be ontology (Easterby-Smith et al. 2000). Epistemology is the assumptions made in enquiring to the nature of reality (Easterby-Smith et al. 2000). It is own one philosophical position that will affect the creation of outcome from any research activity (Saunders 2017) as the philosophical position plays an instrumental role in perceiving the research approach, questions and interpretation of the analysis (Saunders et al. 2009). There are five major philosophical positions or paradigms that were identified during the literature review phase (Saunders et al. 2009):

1) Positivism
2) Critical Realism
3) Interpretivism
4) Postmodernism
5) Pragmatism

The researcher initially focused on positivism philosophy. However, in this approach, the researcher was limited to data collection and interpretation of the collected data, the researcher shifted the focus toward pragmatism. In the Pragmatist way of approach, the researcher can focus on processes that are in context with studies of knowledge and learning (Easterby-Smith et al. 2000). As this research addresses actionable benefits, it was vital to focus the concepts that can support action (Kelemen & Rumens 2012). There are multiple methods that can be applied as a pragmatist as it can gain a view from multiple points that are convincing and functional to strengthen the core of the research. Morgan (2014) claims that pragmatism is often characterised

as a novel way of thinking by a selection of efficient methods to solve about matters that creates problems. The pragmatism philosophy is summarised in Table 6.

Table 6: The Pragmatist Philosophy (after Saunders et.al 2016)

Ontology	Epistemology	Axiology	Typical Methods
- Reality is the practical consequence of any ideas that are generated - Integration of processes, practices and experiences - Rich, Complex, External	- Preliminary focus on problems, practices. - Applied meaning of knowledge - Theories that could be true and are those that enable action - Problem solving	- Research driven by Value - Research initiates by doubt's and beliefs	- In line with research problem and research question - Multiple mixed methods, qualitative, quantitative, action-based research - Emphasis on practical outcomes

4.2 Research Logic

The research design is determined by the logic the researcher implements to approach the theoretical background in the core research (Saunders 2017). There are two major approaches to theory development namely: Deductive and Inductive (Ketokivi & Mantere 2010). In the deductive method, the entire case is driven by theory in contrast to the inductive approach where it is purely driven by data. In the deductive case, the research is based on theory by developing a theoretical framework that can be tested to prove its validity and in the abductive approach, the research initiates with observation and aim to identify pattern that an explain a phenomenon or develop a new theory (Saunders et al. 2009). In this research perspective, a combination of deductive and inductive approach is applied which is termed as "Abductive" (Dubois & Gadde 2002; Kovács & Spens 2005). In this framework, the researcher using prior knowledge of Automobile Supply chains in an end to end context, created an innovation framework that will be tested in the empirical phase as prescribed in a deductive approach. In the terms of analysing empirical data, the inductive approach was followed to design and propose new supply and inventory policies based on the

data analysis. The abductive research logic based on (Kovács & Spens 2005) is depicted in Figure 19.

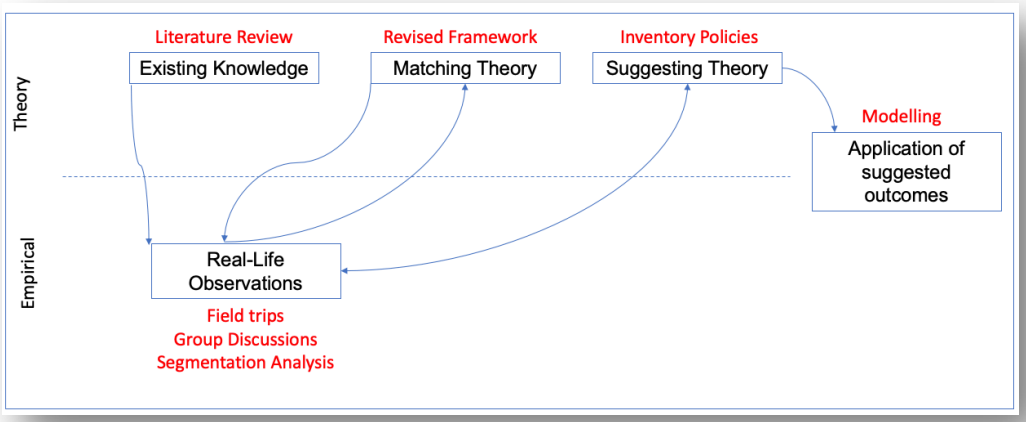

Figure 19: Abductive Logic based on (Kovacs 2005)

4.3 Methodology

There exists a wide spectrum of ontological and epistemological beliefs that can support a wide range of research methodologies (Godsell 2008). However, it is key to ensure that there is a fit between the entire agenda of the research and methodology implemented during the study. According to Saunders (2017), there exists three methodological choices for any research design: Qualitative, Quantitative and Mix methodology. In revisiting the broader objectives of the study, it was essential to examine the current stage of planning process, delivery strategies, performance levels by studying the demand, supply and inventory process in both the companies leading to the development of an inventory model. In addition, further investigation of independent structures and processes are required within and between firms to propose a future state design for integrated planning. This complexity in combination with lack of KPI's and metric advocates a serious case for considering case research methodology (Harrison 1998). However, the need to perform a segmentation process with the already available historic data transforms the approach to quantitative methods. The "mixed-method" methodology proves to be a good fit for this research context where qualitative data analysis can be performed with the case study research at two different companies and upon collection of demand data, a qualitative

methodological approach can be implemented. In this research the triangulation rationale of using the multiple sources of evidence improve the accuracy of the research observations by ascertaining if the findings from one method correspond to the results of the other method can be used (Saunders 2017). A further explanation to prove the validity of this approach is the nature of most of the research questions that are "How" and "Why" questions in nature. According to (Yin 2009), how and why questions are most favourable for the use of case studies or experiments. As most of the questions in this research are exploratory "Why" or exploratory "What" in an end to end supply chain environment with no direct control of the researcher. A reference to Table 7 cites the relevant situations for different research strategies. The case studies to be performed at TATA Steel and JLR comply with the above-mentioned approach. However, multiple-sources of evidence is required in the form of quantitative demand data, qualitative interview and online questionnaire is required, validating the researcher's pragmatism philosophy and mixed methodological choice.

Table 7: Different Research Strategies. Source adapted from (Godsell, 2008, Yin, 1994)

Strategy	Form of Research Question	Requires Control over Behavioural Events	Focus on Contemporary Events?
Experiment	How, Why	Yes	Yes
Survey	Who, What, Where, how many, how much	No	Yes
Archival Analysis	Who, What, Where, how many, how much	No	Yes/No
History	How, Why	No	
Case Study	How, Why	No	

4.4 Phases of Study

4.4.1 Designing the Case Study

As from the onset, two different companies were involved in this study, a multiple case study design was envisioned. Van Aken (2005) augments that multiple case studies can accumulate more supporting evidence and can help generate deeper

understandings of the problems. In this context, the chosen research design has to create the opportunity:

- Describe the current state of art in planning and demand management
- Explain how the current state can be different in terms of the underlying principles
- Integrate these principles in an end-end planning process

In considering these above-mentioned points, the case study for this thesis was designed in a three-point approach as highlighted in Table 8.

Table 8: Research Phases (Source after Godsell, 2008)

Phase	Objective	Case Type	Duration
Company 1 **TATA Steel**	**Study** the current stage of supply planning process, delivery strategies, performance levels and studying the supply and inventory process. **Identify** Enablers and Inhibitors that implicates Business	Point on Time	5-6 months
Company 2 **JLR**	**Study** the current stage of demand planning process and inventory process. **Identify** Enablers and Inhibitors that implicates Business	Point on Time	5-6 months
Cross-Company	**Design** a Future state collaboration map for enhanced inventory management and demand-supply planning. Turn Inhibitors to Enablers		Ongoing, Throughout in addition to 1-2 months at the end

4.4.2 Stages of Research Design

In this study, a five stage approach similar to the model proposed by Stuart et al. (2002) was implemented. The approach is summarised in Figure 20. The research stages were categorised in three categories:

1) Scoping phase (Defining Parameters, Instrument Development)
2) Situation Analysis (Data Gathering and Analysis)
3) Feedback (Stake Holder Workshops)

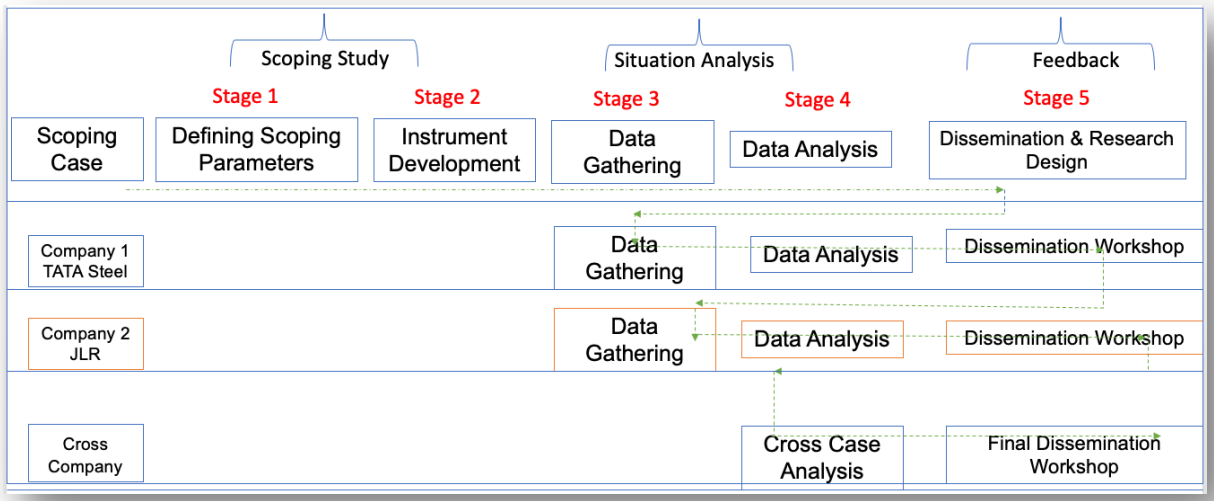

Figure 20: Stages of Research Design (Source adapted from Godsell 2008)

4.5 Phases of Research

4.5.1.1 Scoping Phase

There are two main techniques involved in this research to collect the appropriate data:

1) Primary Data Collection
2) Secondary Data Collection

The primary data is collected by the researcher in forms for exploratory visit, interview notes (Saunders et al. 2009). In the section 4.4.3.4, a detail method for collecting this data source with the instrument development techniques is discussed. The secondary data is often the data that is already collected by other researchers for different studies or internal management reports. However, before collecting the data, it was important to envision the nature of the data which was required to perform the analysis in correlation to the objectives of this research. A set of scoping parameters are developed during the initial phase of the scoping, even before the initial field trips were conducted. The scoping parameters were based on a supply chain maturity assessment tool based on Crimson (2014). The parameters are attached in the Appendix of this report. The primary objective of the scoping study was to stream-line the focus of the data collection during the next phase of situation analysis. It was essential during to phase to informally discuss about the core SC planning activities with the managers involved in the departments relating to this research. This phase helps to identify the problems the companies face, and the right instruments required, to collect the appropriate data for solving the issue. A short illustration of the objectives for the scoping study is highlighted in Figure 21.

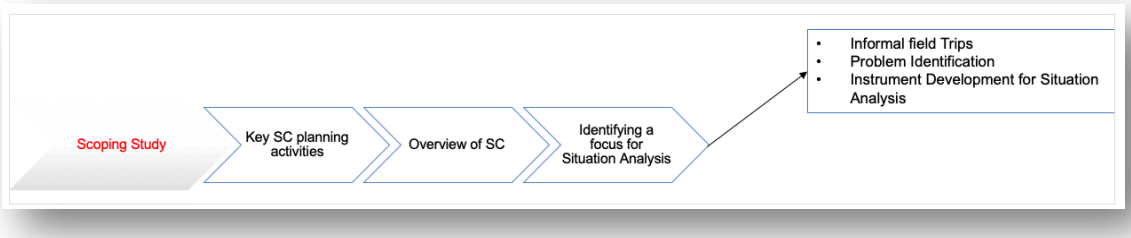

Figure 21: Objectives of the Scoping Study

4.5.1.2 Situational Analysis

In this phase, the primary data was collected in the form of multiple field visits to the respective companies. During the situation analysis phase, the context was to understand the demand, supply and inventory parameters and identify the gaps in process structure within and between companies. A complete list of visits undertaken during the course of the study is highlighted in Table 9. In addition to the physical visits, several tele-conferences were held with all the stake holders on a fortnightly basis for the entire duration of the data collection phase. In this phase, a systematic

review of current planning strategies and production processes were studied along with identifying gaps within and between the firms by a form of a online questionnaire based on (Wong et al. 2012). Several group discussions and semi-structured interviews were held to identify the operation strategy. A big picture map of the current planning and production process was established during this phase of the study. The situational analysis objectives are illustrated in Figure 22.

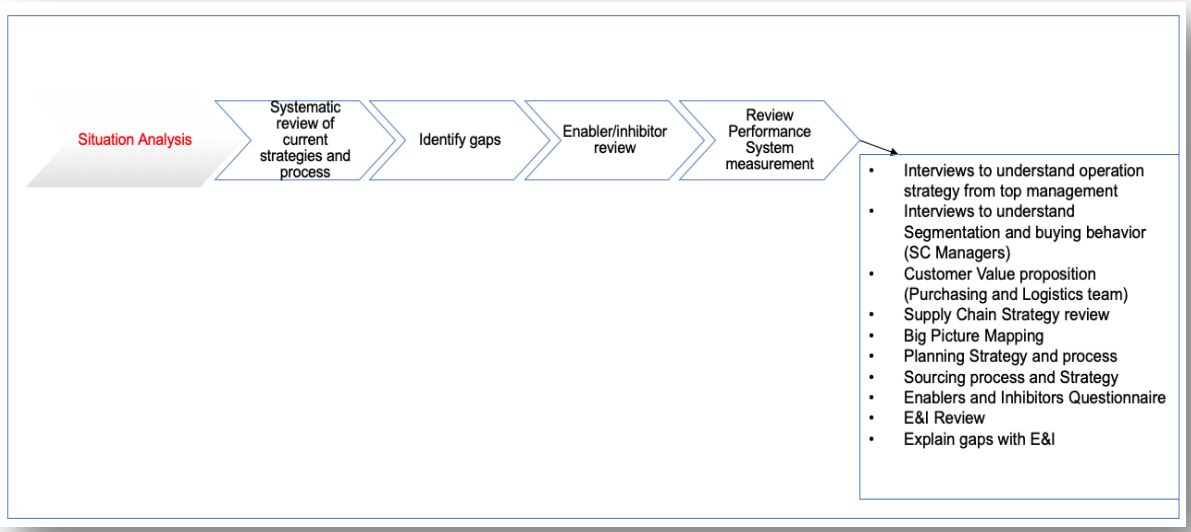

Figure 22: Objectives of the Situation Analysis

4.5.1.3 Feedback

As shown in Table 9, several feedback sessions were held in the form of dissemination workshops with the stakeholders of the respective companies who participated in this research.

In this phase, two formats of workshops were conducted:

1. Internal workshops with the analysis of results from the individual case studies.
2. Integrated cross-case workshops were all the stakeholders from both the companies participated.

The reporting template was in the form of presentations. There were five major areas of the research which was highlighted during the course of the feedback: “Big Picture Map” with pragmatic future state map, current and future collaboration practices based on a maturity assessment tool, Enabler and Inhibitor Analysis based on the results of the online questionnaire, segmentation analysis of the quantitative data, future state inventory modelling.

Table 9: Calendar of Events

Dates	Phase	Scope	Team Involved	Location
24.03.2017	Scoping	Project Description	WMG & TATA	WMG
25.05.2017	Scoping	Project Description	WMG &JLR	WMG
10.11.2017	Scoping	Informal visit	WMG & TATA	Llanwern
06.12.2017	Scoping	Informal Visit	WMG & JLR	Halewood
06.02.2018	Scoping	Finalizing the scoping visits	WMG& TATA	Llanwern
12.02.2018	Scoping	Finalizing the scoping visits	WMG & JLR	Halewood
24.04-27.04.2018	Situational Analysis	Primary data Collection	WMG&TATA	Llanwern
18.08.2018	Feedback	Feedback of initial results	WMG & TATA &JLR	WMG
26.06.2018	Situational Analysis	Additional data collection	WMG & TATA	Wednesfield
13.07.2018	Situational Analysis	Primary Data Collection	WMG& JLR	Halewood
26.09.2018	Feedback	Final Workshop with Dissemination of results	WMG & JLR & TATA	WMG

4.5.1.4 Instrument Development for the Case Study

Yin (1983) identifies six different source of evidence that can be used as a part of the case study research (Godsell 2008):

1) Documentation
2) Archives
3) Interviews

4) Direct Observation
5) Participant Observation
6) Physical Artefacts

The primary source for this study was semi-structured interview. Interviews have huge benefits to focus directly on the subject to investigate in depth whilst providing causal inferences for the interviewee (Yin 2006). A case study protocol was established to define procedures that can govern the use of the information in a reliable way. The case study protocol designed after (Godsell 2008) had three main elements: field procedures, interview notes and reporting protocol. The field notes were designed to set the context of the study and to define the approach, the resource required and the timing for the scoping study. The main context in the interview protocol and a standard reporting procedure in the form of dissemination workshops were designed for this research. This enabled the researcher systematically to understand the planning capabilities in both the companies and determine the focus on data collection for the situation analysis phase of the project.

The researcher followed the three independent principles that underpins the data collection suggested by Yin (1983):

1) Using multiple sources of evidence
2) Creating an explicit case study database
3) Maintaining a chain of evidence

4.5.1.4.1 Using multiple sources of Evidence

As the qualitative data collection exercise was primarily in the format of field work. During the numerous field visits and informal meetings, a standard contact note was used to document the developments. The researcher transcribed all the important aspects of the meeting in a personal notebook but within a day turned them in to a word based contact note format suggested by (Miles & Huberman 1984). An internal decision was taken to use this sample note as a primary raw source of data. A template of the contact note is illustrated in Figure 23. In the course of study, various set of

secondary data were collected like historic demand data and various technical notes. They are annexed in the section 6.0 of the contact notes. The contact notes are annexed in the appendix chapter 9.2 of this report.

FIELDWORK - CONTACT NOTES

Interviewee		Transcript No.	
Job Title		Date	
Contact Details		Location	

1.0 INTERVIEWEE BACKGROUND

2.0 MAIN ISSUES OR THEMES ARISING

3.0 SUMMARY OF INFORMATION GATHERED

4.0 OTHER SALIENT, INTERESTING, ILLUMINATING OR IMPORTANT ASPECTS

5.0 NEW/OUTSTANDING QUESTIONS FOR NEXT VISIT

6.0 SECONDARY DATA

Figure 23: Contact Note Template after (Miles and Huberman 1984)

4.5.1.4.2 Creating a Database

The case study data base as listed in appendix 9.2 was created to track of all the primary and secondary sources of data. Most of the secondary data was in an electronic format and was stored in a dedicated project folder. An example of a case study database is highlighted in Figure 24.

TATA Steel
Case Study: Summary of Key Documents

Date and Location	Ref	Interviewee	
		Name	***Role***
10.11.2017 TS Head Office Llanwern	ID#1	SW	Director SC Fulfilment
20.03.2018 Telephone Conference	TF#1	MA	Head of SC Fulfilment
24.04.2018 – 26.04.2018 TS Head office, Llanwern, UK	GD#1	MA	Head of SC Fulfilment
	GD#2	JP	Customer Service Team
	GD#3	CJ	Customer Service Team
	GD#4	CL	Automotive Replenishment Manager
	GD#5	AD	Manager Weekly S&OP
	GD#6	MR	Design Lead
	GD#7	HH	Replenishment Controller
	GD#8	CM / SF	Scheduling Manager & Process Lead
	GD#9	SW	Director Fulfilment

ID= Initial Discussion, TF= Telephone Conference GD= Contact Notes from Group Discussions

Note:
This list only corresponds to primary data sources. The secondary data sources are listed in the relevant contact notes forming a chain of evidence.

Figure 24: Case-Study Database Template (after Godsell, 2008)

4.5.1.4.3 Maintain a Chain of Evidence

This document is a combination of recorded notes within the case-study database and the presentations made during the feedback of the project. The overall objective was to link the chain of evidence for the primary data collected in each individual case study with the secondary data collected for the analysis. The case study database with the contact notes and the necessary quantitative data collected during the study form a chain of evidence in this study.

4.5.2 Research Method

The entire research method was based on the four stage design based on Godsell et al. (2011), this is summarised in Figure 25.

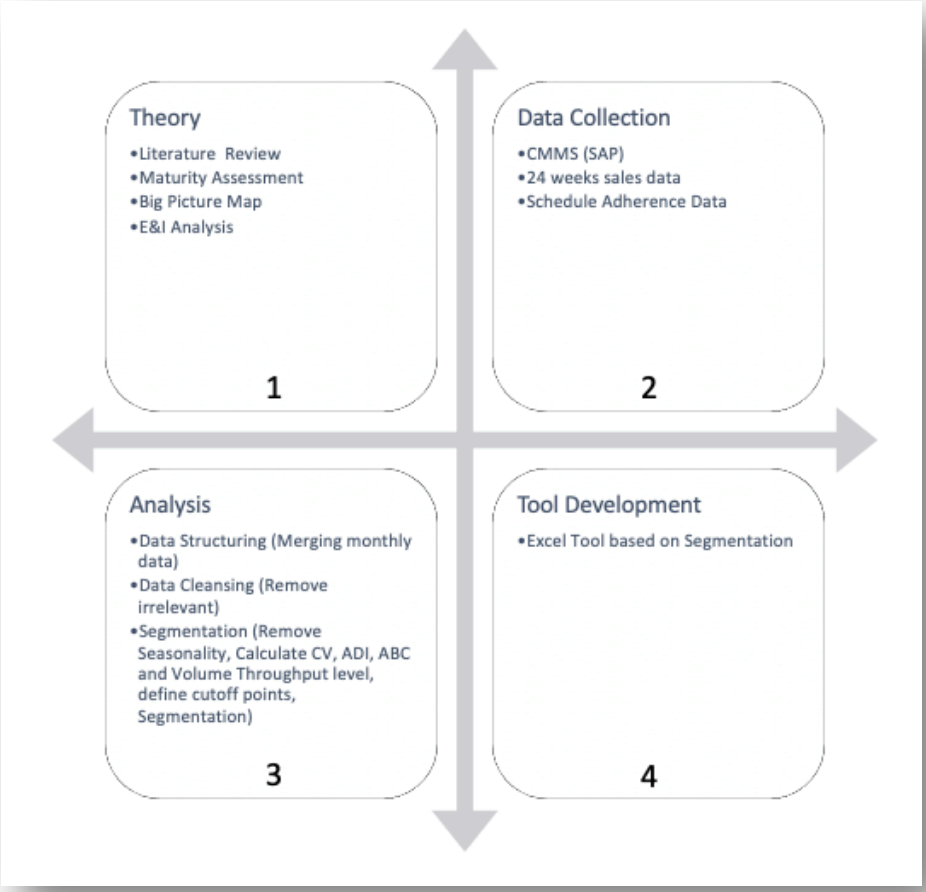

Figure 25: Research Method (after Godsell 2011)

The first stage of literature review was performed in multiple portfolio submissions namely manufacturing strategy, productivity and supply chain leading to an Innovation framework. Some informal trips to both the companies were conducted before the

actual case study commenced. The case studies were conducted to obtain the qualitative data required to perform the E&I analysis and draw a big picture map to complete the theoretical framework. The demand and schedule adherence data were obtained from the ERP software's at the respective companies that facilitated the analysis and data.

4.5.2.1 Informal Visits

The researcher conducted four informal visits (two visits to TATA and two visits to JLR) before the field trips were conducted to initiate the case study. The trips were of exploratory nature to obtain a helicopter view of the companies to understand the supply, demand and inventory processes. The template of the meetings was more presentation of processes from the company managers involved in these departments and often ended up with a tour in the premises. The informal visits were held in two different sites at TATA (Llanwern and Wednesfield) and at Halewood assembly plants. The second informal visits were more of consensus meetings to formulate the problem of research. Due to ethical requirements, the visit details are not included in this report.

4.5.2.2 Qualitative Data Collection

In this case study, there were three different phases of qualitative data collection: Semi-structured Interviews to perform a maturity assessment exercise, group discussions to draw a big picture map and formulating a "Qualtrics" based online questionnaire for the Enabler and Inhibitor Analysis.

4.5.2.3 Maturity Assessment

As the study focussed in improving productivity, it was essential to identify attributes of processes with-in and between companies that will drive extra competitive advantage in comparison to its peers. A maturity assessment exercise was planned to understand of the company was doing the right things and if they have the right people with the right capabilities and if they understand what to do. This was performed based on semi-structure interviews, as this allowed a better understanding of the real-life situation with standardised interviews being pre-coded and

accumulation of any additional information will be difficult (Frøkjær et al. 2000). However, the risk of the semi-structured interviews was that the alignment of the interviews is difficult due to various other topics discussed during the interview. This exercise conducted face-face and it covered all aspects of demand management, supply management, S&OP planning, operations and Managerial implications. In total there were 10 interviews held at TATA's two premises and four interviews held at JLR's premises. Due to the ethical considerations, only the notes which do not correspond on managerial barriers are annexed in the appendix of this report.

4.5.2.3.1 Group discussions

As both companies are involved in a complex supply chain and are located at various locations across the country, it was challenging to draw an entire process map covering all functions across the length and breadth of the company. The nature of jobs in operations meant that teams were working in shifts and any emergency action had serious effects in this project, in terms of time. During the data collection phases, there were numerous occasions when the meetings got postponed or even cancelled. There were multiple stake holders involved across the value chain of the company and the project was dependent of every single group to participate in order to get the deliver a big picture map. During the meetings, the stake holders discussed their various processes, operation practices, bottlenecks and troubleshooting techniques. Despite the steel / automobile industry being traditional, there were several intellectual property issues which were considered before the information was collected at the group discussions:

1) Technical information is not published and is being illustrated only as headlines in the big picture map which can be used only for the participants of this research.
2) Managerial challenges are anonymised in the E&I analysis.
3) No internal documents were distributed between the companies.
4) All the notes were deemed to be confidential so only samples of the contact notes are attached in the annex.

5) A “Non-Disclosure-Agreement” was in place for this project between the companies in addition to the Ethical approval of the university.

The big picture map was made during the course of these discussions and it was mutually agreed to disseminate only for this project consortium.

4.5.2.3.2 Enabler and Inhibitor Analysis

The E&I analysis was primarily performed to study the structure and processes within and between the companies involved in this research. The study was also important in finding the business implications that affect the overall productivity of the companies involved in an end-end value chain. In order to conceptualize and build a model for the study the researcher use the updated framework on supply chain alignment developed by (Skipworth et al. 2015). The original framework developed by (Wong et al. 2012) identified six enablers of supplier and customer alignment. A detail description of the enablers will be discussed in Chapter 5.1.1.2. The tool for the analysis was an online “Qualtrics” based questionnaire and was circulated to identical groups (role) as listed in Figure 26. The results of this section will be showcased in 5.1.1.2.

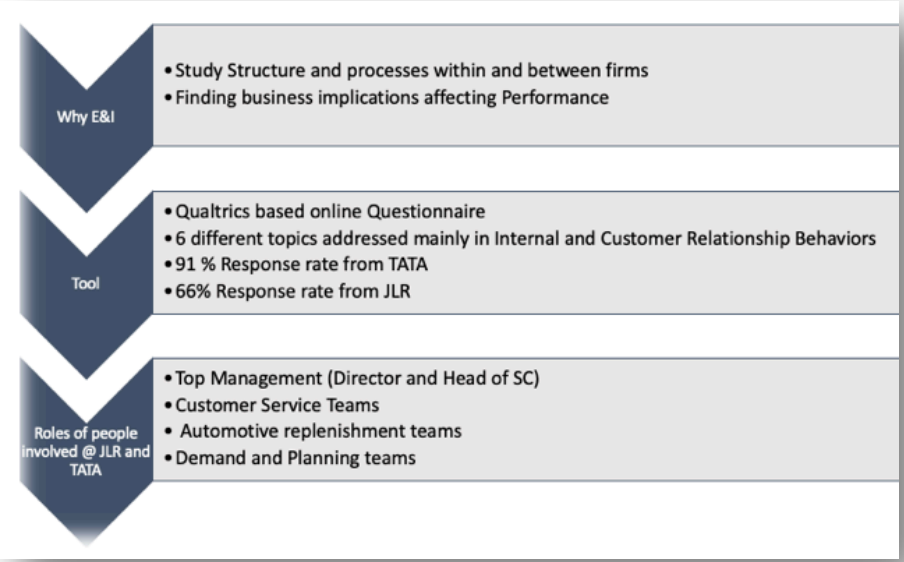

Figure 26: E&I Analysis

4.5.2.4 Quantitative Data Collection

In this phase, an analytical approach was required for performing the analysis. After the field trips were conducted, an initial assessment of the current supply chain processes and performances was made to collect the appropriate qualitative data. This assessment is summarised in Table 10.

Table 10: Analytical Approach

Section	Demand	Supply	Inventory
Core Questions	1) Identify the demand profiles of FG's in to Halewood 2) Accuracy of the demand forecast for FG's	1) Policy effectiveness of supply 2) Conformance of production schedules 3) Stability of production plan	1) Inventory balance across the network 2) Service levels
Topics	- Demand Segmentation - Forecast Accuracy - Forecast Stability	- Plan Policy Analysis - Conformance to plan & Schedule - Plan Stability	- Stock Distribution, sales and availability

There were major constraints in data collection due to new SAP systems, the historical data set was available for 24 weeks, starting from the 1st of January 2018. As the scope of research was identification of the challenges within the indirect supply of TATA steel. The core analysis concentrated on the 31 external blanks supplied in to Halewood using data gathered from three sources:

1) Round Oak Site (Automotive Stocks, on hand pieces, on hand weight)
2) Wednesfield Site (Weekly Deliveries, call-off, Forecast)
3) Halewood Site (Weekly Receipts, 4-week demand, Stock in Armitts, Halewood Weekly Stock Level)

The press shop data was integrated with in the Halewood data and no separate data for press shops was available. Hence the data provided from the Halewood site, is an approximate data of the consumption at the press shop.

4.5.2.4.1 Data Considerations and Assumptions

There were several assumptions made before the analysis was conducted. The researchers received various sets of data from different sources like schedule adherence team at TATA Llanwern, JLR's production planning team and Wednesfield team. TATA's SKUs were categorised with different SKU numbers when it was pulled off at Halewood. The basic assumptions were that all figures were listed in pieces with data for week 13, 18 and 22 missing due to production stoppages. The site stock flow calculation assumes that non-Armitts stored parts are delivered direct to Halewood from Wednesfield. The researcher used the outbound deliveries as a proxy for production due to data availability. Only the blanks were considered in the analysis.

4.6 Quality of Research

The quality of the research is classified in two primary criteria (Saunders et al. 2009): Validity and Reliability. The criteria's refer to the consistency and the applicability of the results when studied numerously (Kothari et al. 2014). The validity of research often refers to the relationship between practice and reality. The quality of this process help the researcher to defend the results to be valid (Saunders et al. 2009). In this study, the researcher validated minimised biases in asking the similar context of questions, to people involved in similar roles within and between the companies. The research is deemed to be reliable, when the research yield the same results when duplicated by other set of researchers (Yin 1983). The researcher ensured consistency in careful designing of the study with clear explanation of the entire data collection and analysis conducted during the phase of the entire study. The key documents are documented in an organised manner and recorded with all the ethical considerations. The literature review has a comprehensive analysis of all the fundamentals of manufacturing strategy explaining the process evolution of companies that has shifted focus on delivery performance which is the core

requirement for this research. The process mapping in an end-end planning process, in a complex SC that showcasing better collaboration practices demonstrate a high importance to companies involved in similar planning exercises. The segmentation analysis in an end-end planning clearly addressed the “What” question to the entire organisation and managers can now prioritise their resources based on this analysis.

4.7 Summary of the Chapter

The chapter explained the procedure the study will follow, with the researcher’s philosophical position and the rationale of the chosen methodology explained along with appropriate data collection methods used during this research. The phases of the research were described along with the instruments developed to perform the study.

5 Analysis and Results

"A good decision is based on knowledge and not on numbers"

Plato (427-347 BC)

5.1 Chapter Outline

This core chapter of this research defines the approach and techniques that were applied to perform the qualitative and quantitative analysis. After the chapter outline, the section 5.1.1 presents the analysis of the scoping study, interview and group discussions. The section 5.1.1.1 is dedicated to big picture map of processes on material and information flow in the respective companies. The sections 5.2.1.2 are about the identification of the E&I. The segmentation analysis will be underpinned in section 5.1.2 and the qualitative and quantitative results presented in section 5.1.3. The entire chapter outline is illustrated in Figure 27.

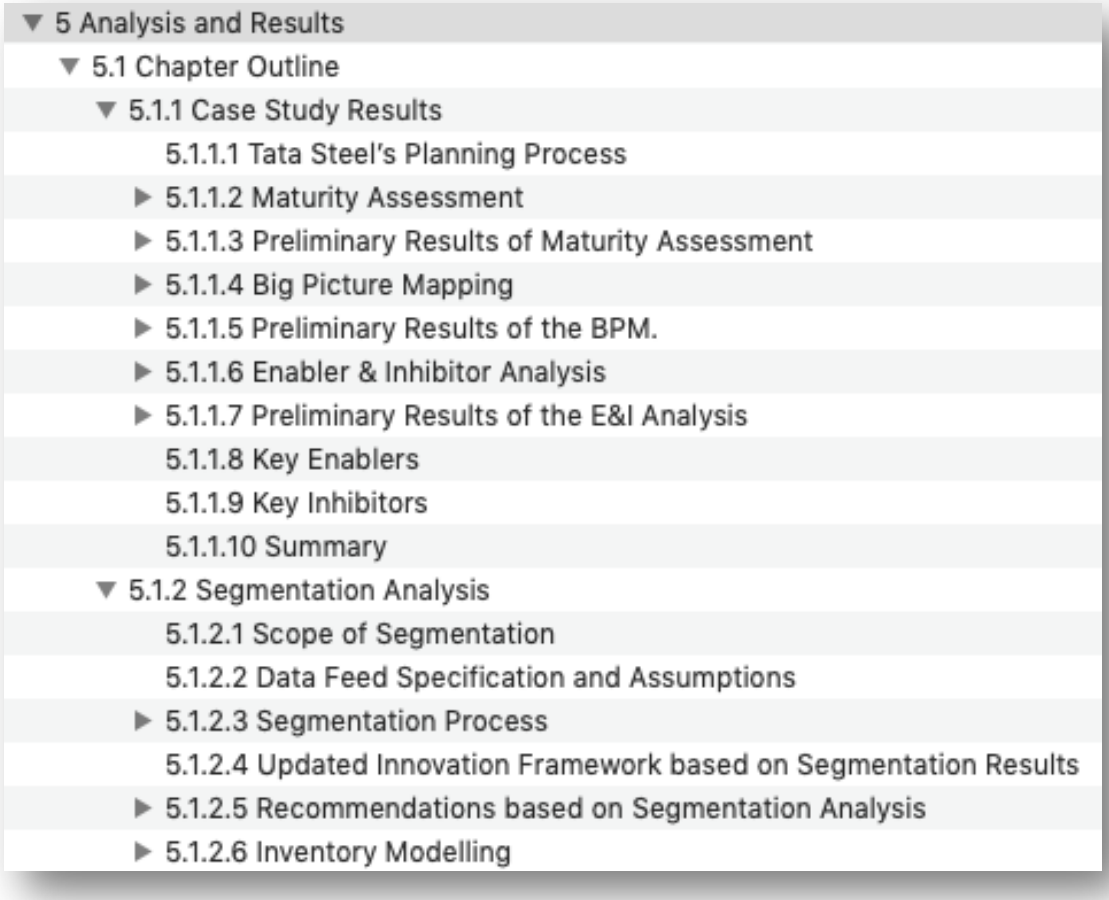

Figure 27: Outline of the Analysis and Results Chapter

5.1.1 Case Study Results

5.1.1.1 TATA Steel's Planning Processes

To set the ground for further analysis it was crucial for the researcher to understand the S&OP process for JLR specific orders. This included order management, order fulfilment, supply planning, Inventory design and production planning capabilities based on customer specific orders. The TATA Steel facilitates a full pressing service to JLR by supplying slit coils, press blanks and blanks in both steel and aluminium from its dedicated centre's at Llanwern and Wednesfield (TATA 2017). On one hand, the "ZODIAC" line at Llanwern adds corrosion protection layers on a number of steel strips, on the other; Wednesfield provides enhanced processing for body panels in steel and aluminium. The scope of this project is limited to steel and the study will concentrate only on the transaction of the steel products with JLR. In the UK, there are three main vehicle assembly plants for JLR:

1) Castle Bromwich Assembly Plant, Birmingham.
2) Halewood Body and Assembly Plant, Halewood.
3) Solihull Plant, Solihull.

During the scoping study, it was determined by the main sponsors for this work, WMG, JLR and TATA steel that the scope of this research will be limited to the Halewood Body and Assembly Plant and the Llanwern and Wednesfield supply sources. In total 33 Blanks and 60 coils are in transaction between the two supply sources. JLR makes 140-150 steel parts for its vehicles from TATA Steel's supply. The press shops run on batches with a batch size of 1500 coils and 1000 blanks. There are two different supply mechanisms offered by TATA Steel illustrated in Figure 28:

1) **Direct Supply**
2) **Indirect Supply**

The decoupling point for the FG's at Halewood is a central warehouse that is called as "Armitts". All the 60 coils from TATA Steel Llanwern are sent to "Armitts" from Zodiac in Llanwern and the out of the 33 blanks from TATA Steel Wednesfield, 22

blanks are sent to “Armitts” and 9 blanks with special specifications are shipped directly to one of the inventories (bypassing Armitts) holding areas at Halewood plant. The FG’s which are shipped directly from ZODIAC to “Armitts” is classified as **Direct Supply** and FG’s that go via Wednesfield to “Armitts” or to the Halewood inventory holding areas is classified as **Indirect Supply**. TATA Steel has two different inventory holding points namely:

1) Wednesfield Distribution Centre
2) Round Oak terminal

The Wednesfield site produces differentiated steel products knowns as tailor welded blanks for car body (TATA, 2017). In addition to JLR, it supplies to Honda, GM and Nissan. TATA steel has its own dedicated railway terminal at Round Oak that provides a direct train link to the warehouses, 10 times per week. Both these centres hold inventory for JLR SKUs.

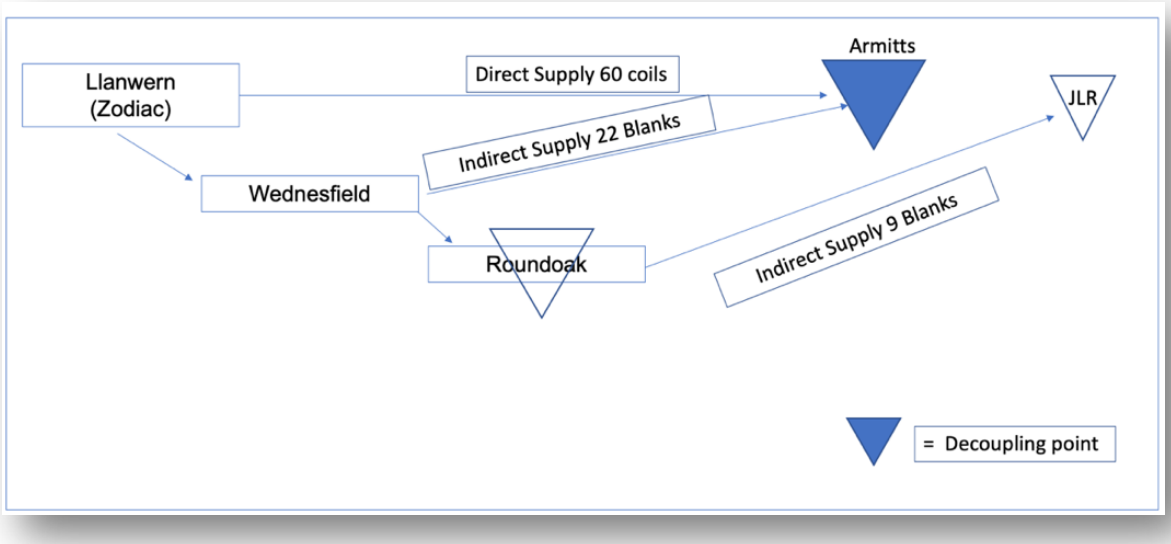

Figure 28: Direct Vs Indirect supply

TATA steel has several IT platforms in place to deal with information flow from JLR. The backbone platform is based on SAP. The RAPID is a data reporting system which sends demand data to the Factory Planner (FP) that coverts demand in to a production plan. The system DILO is used to refresh demand data on a daily basis as there are

no live feeds available. BRONER facilitates sequential production planning, while STACCA, COMPASS is MES System. However, the entire ordering and execution processes are performed in SAP. The IT systems are listed in Table 11.

Table 11: IT Systems dealing demand from JLR

System	Description
RAPID	Data Reporting System
FP	Factory planner that converts demand data in to production plan
DILO	Updating demand on a daily basis
BRONER	Sequential Production System
STACCA	MES
COMPASS	MES
STRATIX	ERP

The order management process at TATA Steel has an order prioritisation system based on an assigned colour called “Theory of Constraints” (TOC) in order to achieve throughput optimisation as well as to minimise inventory and operating expense. A colour code will demonstrate a uniform impact on the customer or the next process. Order Management Processes normally fall in to two categories:

- Orders which replenish a decouple point (MTA/MTF). These orders are coloured based on principle of buffer penetration.
- Orders which are linked directly to a customer order (MTO/FTO). These orders are coloured based on lead time penetration. The colour codes are listed in Table12.

Table 12: Colour Design Rules for Order Management (Source: TATA Steel)

Colour	Decoupling Point Status (Emotion)	Order Action (Emotion)
Black	The customer has been let down as the commitment is not been fulfilled	Everything needs to be mobilized to get the order working
Red	Stocks are available but below targeted levels or order is running behind Lead-time	Prioritize orders
Amber	Fine, Normal	Work as normal
Green	Some additional stock that expected or order is ahead of lead-time	Only work it when you have got nothing else to work
Blue	Too much stock in the chain or order is launched too early	Do not work

The dynamic buffer management (decoupling stock levels) is a responsibility of the "Order Fulfilment Team" and is linked directly to the order fulfilment strategy as illustrated in Figure 29.

1) For MTF Decoupling points the colours will be allocated based on the amount of the stock at a specific decoupling point compare against the number of weeks it can cover future demand (actual orders and schedule agreements).
2) MTF replenishment orders are coloured based on the projected net stock positions at the moment in time the order is planned to arrive at the decouple point.
3) For MTA decoupling points, the colours will be allocated based on the amount of stock at a decouple point compared against the total pipeline target.
4) MTA replenishment orders are coloured based on projected net stock, reduced by the actual average demand.
5) MTO lead time penetration is based on delta between due date and the minimum completion time.

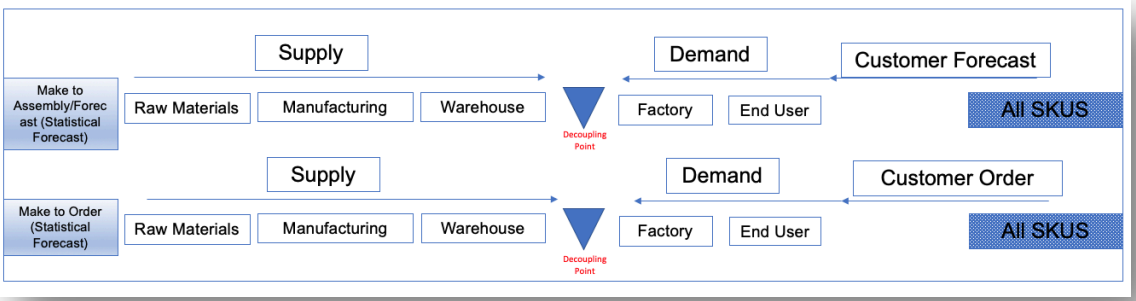

Figure 29: Order Fulfilment methods

The S&OP team with in the Supply Chain department that pulls the latest forecasts from JLR, gather all the necessary demand data and perform an historic pattern check on the forecasts they receive. The S&OP team makes a monthly make and a sale plan. The team then splits the demand in weeks in correlation to the weekly capacity constraints for 26 weeks of orders. The S&OP team uses the MTF method for all automobile customers including JLR. The replenishment strategy is based in orders that are of priority using a safety stock approach. All the SKUs are ranked in a dashboard using colour coding mechanism as highlighted in Figure 30.

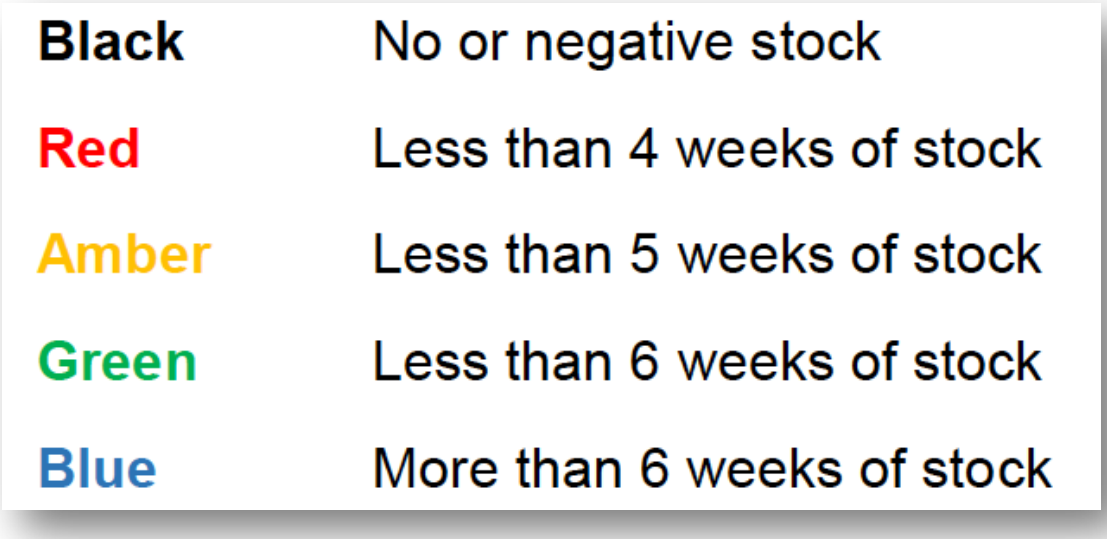

Figure 30: Safety stock approach based on Colour codes

Black and red denotes to a negative stock (Red for missing customer requirements, Black for stock out), while Green and Blue denotes to a more stocks (over 5 weeks). The optimal colour is Amber (less than 5 weeks of stocks). The yields are calculated

for individual SKUs and incorporated in the safety stocks. The service levels are measured by OTIF delivery. The data reporting system "RAPID" operates with in a selection of colour coding rule sets that have been designed to drive the colour coding of orders in line with customers' requirements as listed in Table 13.

Table 13: Theory of Constraints Descriptions

Rules	Description
B0123	Black <= 0 week, Red = 1 week, Amber = 2 weeks, Green = 3 weeks
B01246	Black <= 1 week, Red = 2 weeks, Amber = 4 weeks, Green = 6 weeks
B0246	Black <= 0 week, Red = 2 weeks, Amber = 4 weeks, Green = 6 weeks
B0446	Black <= 0 week, Red = 24weeks, Amber = 4 weeks, Green = 6 weeks
B0123plus	Same as b0123 but if Black and Physical stock is > ½ of Red Value then Red
B0246 Plus	Same as b0246 but if Black and Physical stock is > ½ of Red Value then Red

These above-mentioned colour rules facilitate to customise individual SKUs to level their stock replenishment with the agreed customer stock-holding levels. The "ToC" is integrated with the Factory Planner (FP) in the capacity planning stage. During this phase, RAPID will send FP a form which contains "ToC" offsets to orders based on lead time or buffer penetration. The "ToC" offset is applied to the due date of the demand and not the individual production order. It should be noted that "ToC" offset applied to a sales order with FP. Based on the "ToC" offset provided by RAPID, the due dates of the demand are amended. The material assignment in FP follows the below sequence:

1) Due Date
2) Priority
3) Quantity

In this respect, "ToC" offsets are used in the priority form within in the FP. Summarising this section, the S&OP at TATA Steel was explained with the ToC policy used by the supply management teams. The team uses dedicated OFID reporting systems for all

customers and SKUs with some minimal inventory decisions based on historic demand. The OFID suite contains a range of available service levels and performance reports for various customers, products, and SKUs. The root causes analysis for the Black SKUs need to be still identified for specific SKUs for specific customers.

5.1.1.2 Maturity Assessment

During the course of the field trips to TATA Steel, a qualitative maturity assessment was conducted to understand the performance weakness and prioritise improvements. The maturity assessment was conducted using a supply chain improvement tool called "scPrime Process Capability Framework" (Crimson 2014). This tool uses the best practice practices, detailed process descriptions and in-depth people capability profiles to offer businesses a unique way to assess their strength and weakness and evaluate how good they are in a specific business process and offer recommendations for improvements, ensuring competitive advantage through its supply chain. The main topic chosen for this study are summarised in Figure 31. As this research is based on end-end planning of supply and demand management, these topics were deemed to be appropriate for analysis. The process capability framework is based on process definitions that provide comprehensive view of best practises across the SC, enabling improvements to take place (Crimson 2014). The process definitions are at detailed level and reflect best practices based on real experience and allow a allow a through and objective assessment of strengths and weakness across operations within or between companies. The topics with assessment questions used during the study are annexed in the appendix of this report. The sections like policy, process, planning horizon, involvement and forecasts are assessed during this exercise to evaluate how these processes are aligned with the overall business needs of the organisation. There are three elements of assessment with in this S&OP profile:

1) Competency
2) Proficiency
3) Mastery

The objective of this exercise is to indicate the current state of the S&OP profile for this particular department and recommend enhancement strategies to improve the productivity. The proficiency is identified by the method of semi-structured interviews with several individuals within the S&OP team. During this research, the researcher conducted a full day assessment with customer relationship teams, planning, scheduling, demand management and replenishment teams. The assessment profiles are annexed in the appendix of this report. The discussions were recorded in the contact notes and was presented to the top management at the feedback workshop held on the 26th of September 2018.

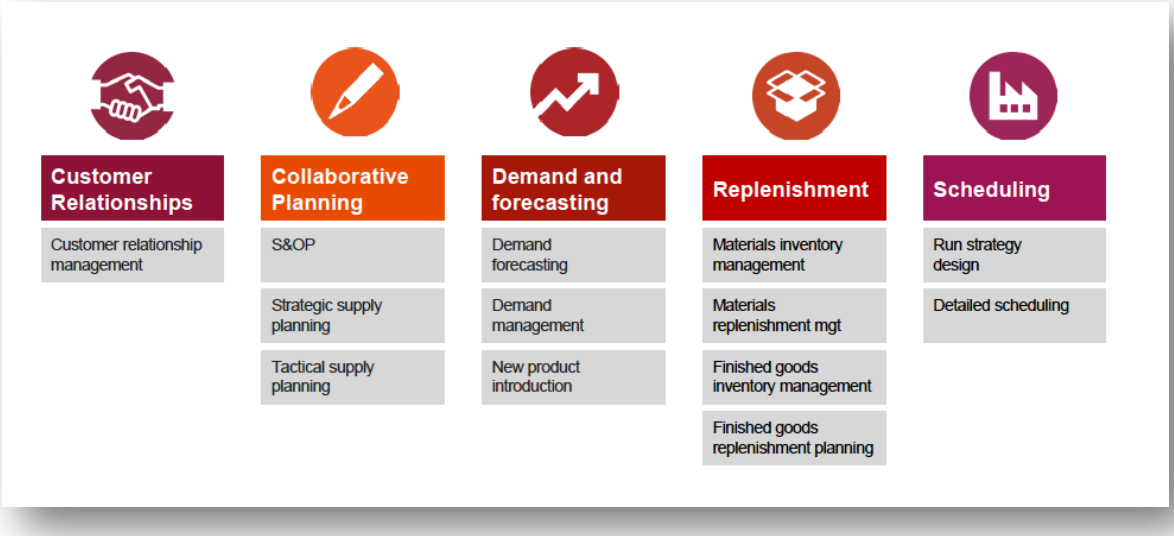

Figure 31: Topics for Maturity Assessment based on (Crimson 2017)

5.1.1.2.1 Competent

If the department is categorised after the assessment as a competent profile, then the S&OP process highlights some of these underpinning attributes (Crimson 2017) :

1) Process in documented with defined scope, participants, inputs and outputs for each stage.
2) Meeting dates are circulated at least four months in advance
3) Standardised document formats are used
4) The process indicates basic integration of demand and supply management

5) Any new product is managed as a part of S&OP process

5.1.1.2.2 Proficient

If the department is categorised after the assessment as proficient profile, then the S&OP process highlights some of these underpinning attributes (Crimson 2017) :

1) The S&OP process documentation is regularly updated
2) The S&OP process documentation is easily assessable
3) The S&OP process defines the outline agenda, inputs and outputs for each meeting
4) The monthly cycle consists of pre-planned meetings, with each process step using a short meeting to review and approve recommendations
5) The output of S&OP process defines the single recognised operating plan for the organisation
6) Volume and Financial data are reconciling a bottom-up and top-down pattern.
7) The S&OP process is the key decision-making forum for the business, and the decisions it makes are adopted and actioned throughout the organisation.

5.1.1.2.3 Mastery

If the department is categorised after the assessment as Master profile, then the S&OP process highlights some of these underpinning attributes (Crimson 2017) :

1) The S&OP process is reviewed at least annually and its improved and updated according to requirements
2) The S&OP team members review process effectiveness after each cycle
3) The S&OP policy includes expected decision-making rights (what/why/who/how) by step and overall
4) The S&OP process produces the majority of required information for the annual budgeting process.
5) Monthly gaps versus strategy and budget are analysed with closing actions driving improvement prioritisation.

6) Key decisions are supported by appropriate analysis and business cases of alternate scenarios including sensitivity analysis.
7) All assumptions and business cases are documented.

5.1.1.3 Preliminary Results of Maturity Assessment

5.1.1.3.1 Customer Relationships

The preliminary indicators based on the semi-structured interview and the group discussions point out a “Competent” profile for this “Customers Relationship” field as the overall approach of the team was reactionary with no formal process in a multiple layer of customer contact points. There were some collaboration measures that existed, but it was not widely understood by the entire team. It was interesting to find out that despite the value and volume of transaction of transaction with JLR, there were no legal “Supplier Liability Agreements” were in place, considering that TATA and JLR are sister companies. The summary of this profile is illustrated in Figure 32.

5.1.1.3.2 Collaborative Planning

The preliminary indicators point out that the S&OP process is of a “proficient “profile while the strategic supply planning and tactical supply planning are of “competent” profile. There is a clear monthly to weekly transition between the different levels of S&OP process and most of the long-term business plans are embedded and aligned with the S&OP process. The supply control techniques reflect the customer demand pattern (MTA, MTO, MTA) and the team has recently introduced the yield analysis data within the wider spectrum of planning. The team also uses advanced analytics modelling for long term capacity planning. The summary of this profile is illustrated in Figure 33.

5.1.1.3.3 Demand Management

The preliminary indicators point out that all the fields with in demand and forecasting profile falls in the category of “Competent”. The demand is forecasted on the basis of the actual customer schedule and the entire demand is extrapolated to the entire planning horizon. There are some internal constraints taken in to account to transform

the customer demand and multiple transformations and handoffs in the process increase the noise in the demand. There are signs of strong organisation alignment and customer focus across different teams and the recently introduced NPI process provides good foundation for progress. The summary of this profile is illustrated in Figure 34.

5.1.1.3.4 Replenishment

The preliminary indicators point out that all the field with in the “Replenishment” profile fall in the “Competent” category. There are multiple MRP systems in place in addition to multiple standalone systems used by individual teams that are working independent of the SAP systems. There appears to be apparent discrepancies with the Factor Planner (FP) allowing levels on the “ToC”. The process is based on high level manual intervention to produce a workable plan. There is an escalation path for unresolved issues based on criticality and risks. The summary of this profile is illustrated in Figure 35.

5.1.1.3.5 Scheduling

The preliminary indicators point out that the scheduling profile highlights a “Proficient” profile as the weekly production schedules are based upon agreed sequencing rules for each asset. There is a flexible schedule horizon and a three-day window for scheduling. The department exhibits robust daily management processes that maintains scheduling integrity and showcases a good working relationship with all the manufacturing units. The summary of this profile is highlighted in Figure 36.

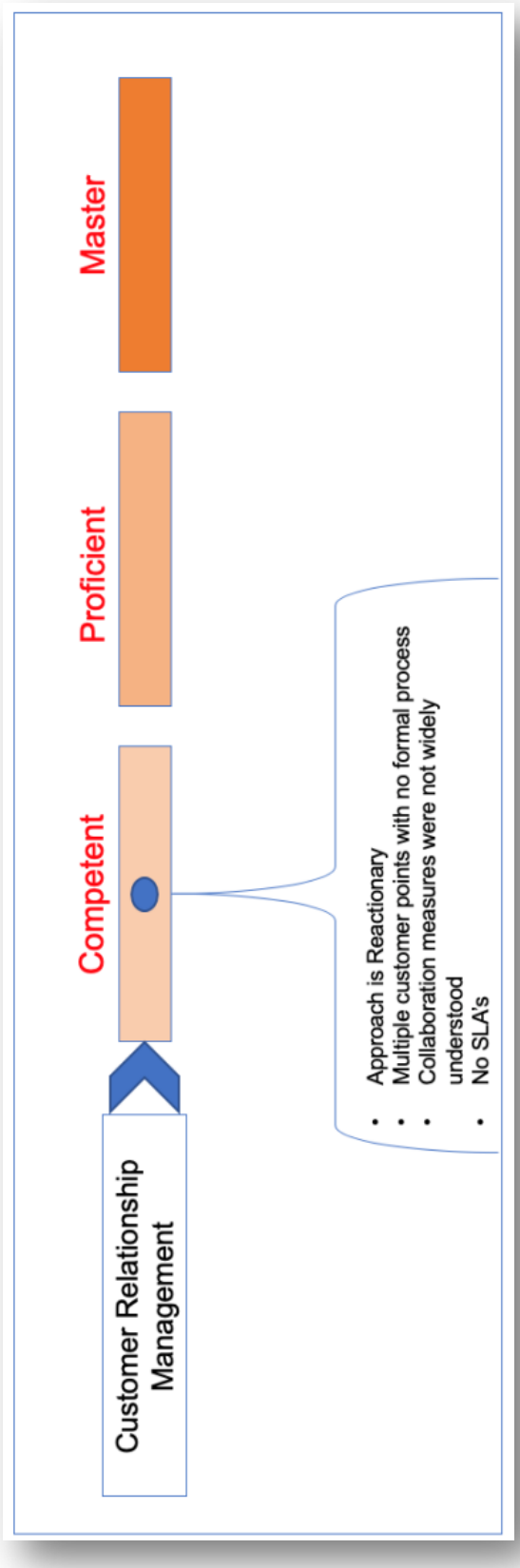

Figure 32: Customer Relationship Profile

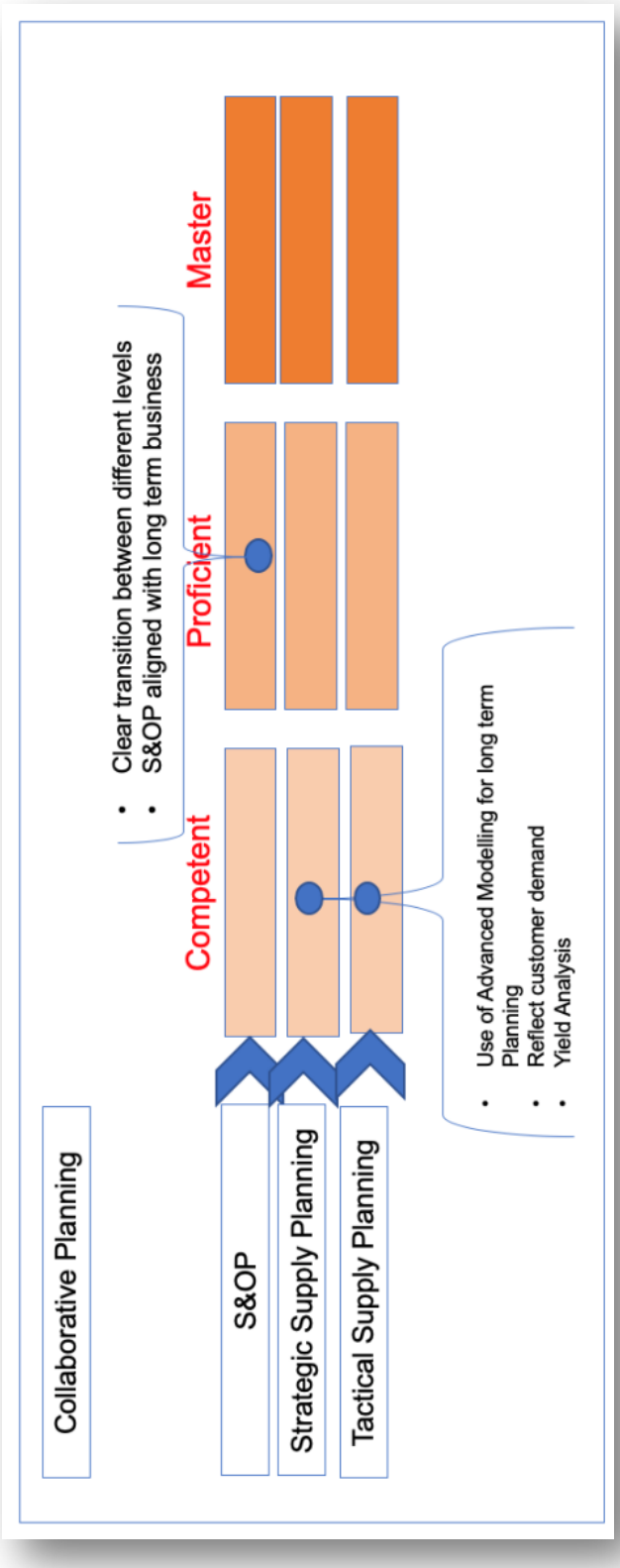

Figure 33: Collaborative Planning Profile

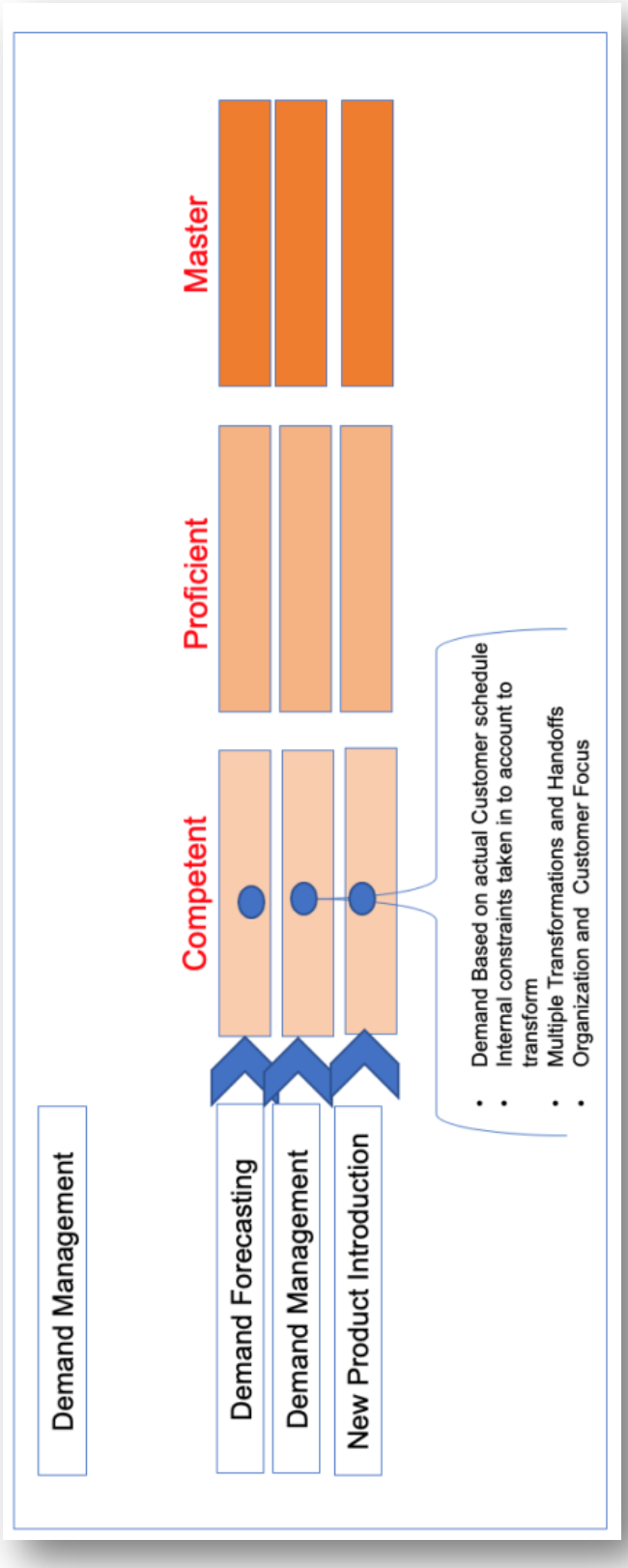

Figure 34: Demand Management Profile

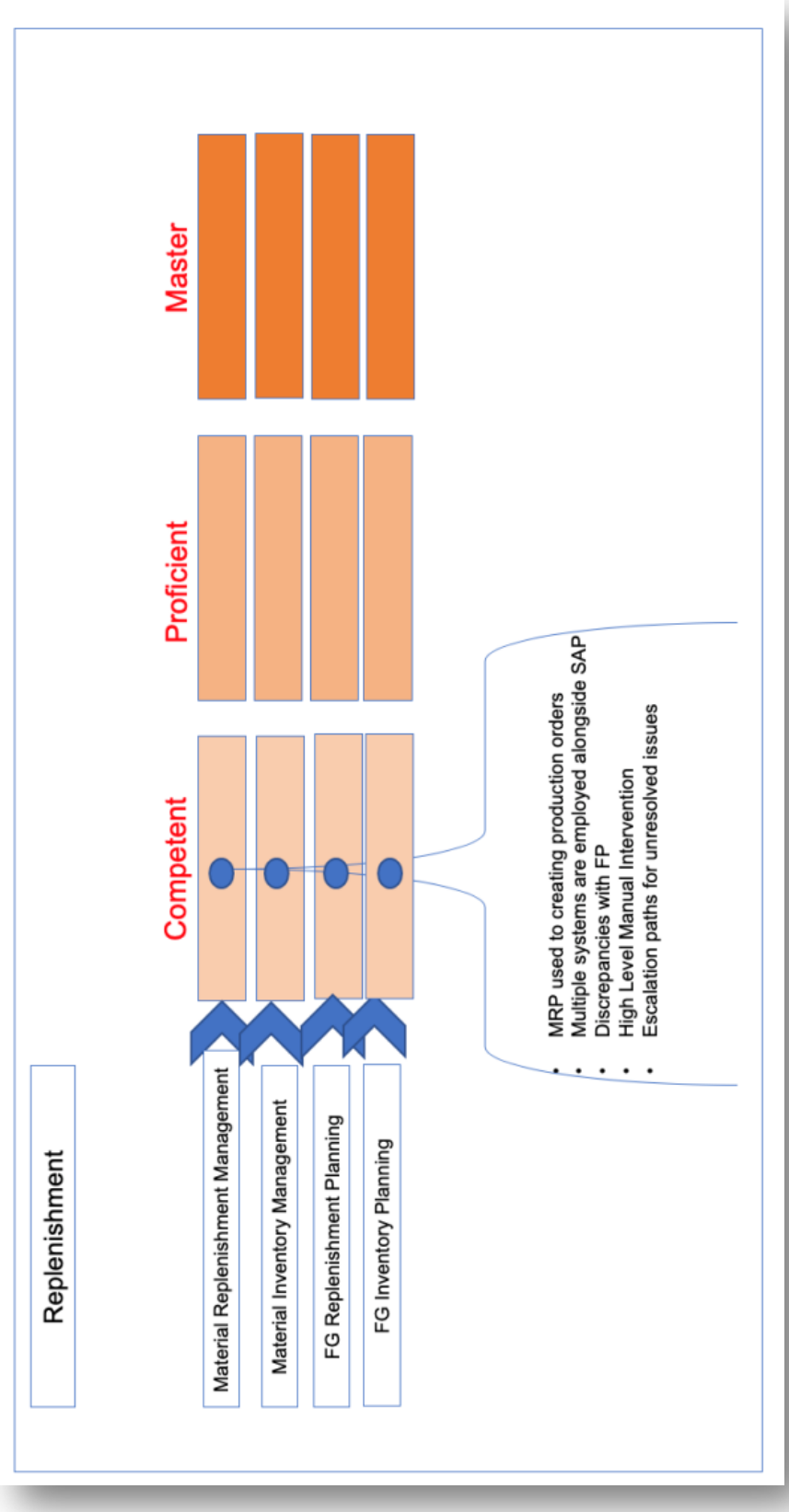

Figure 35: Replenishment Profile

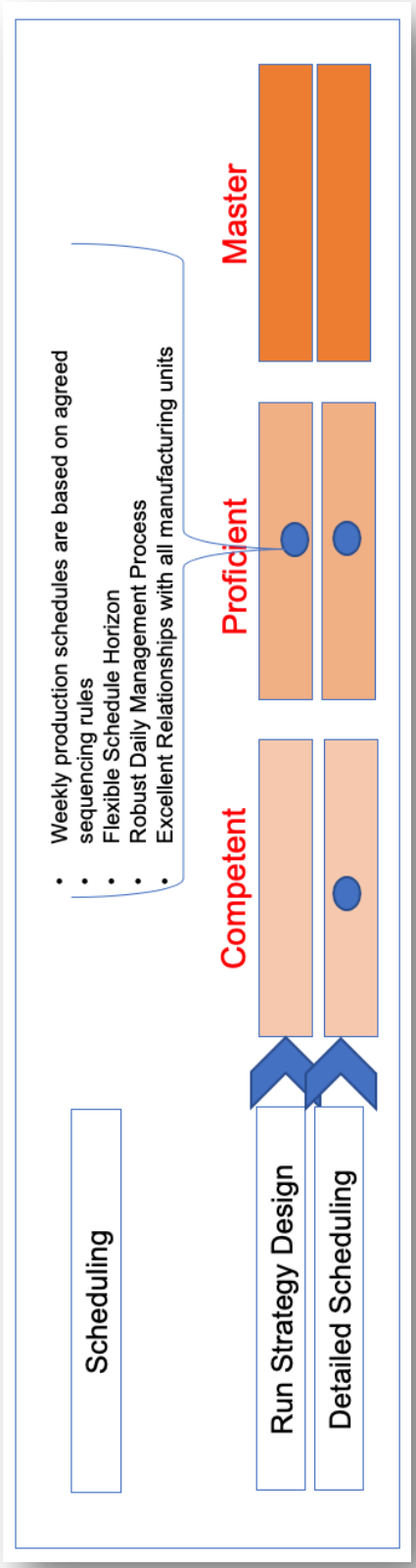

Figure 36: Scheduling Profile

5.1.1.4 Big Picture Mapping

This research study involves a complex supply chain network of two companies involved in various supply & demand management techniques, production planning methods and information flows. A good visual representation of the material and the information flow enables the organisations to understand their core processes, hand-off procedures and identify waste in the system (Griffin-Cryan et al. 2011). However, as the network of systems gets bigger, with multiple cross functional processes within and between companies, the challenge becomes tougher to visualise the process steps that can transform the customer request in to delivered products. The main objective was to identify if there are any non-value-added operations in the value chain that hinders the overall performance. During the group discussions in the field visits to TATA and JLR, a low-level, visual presentation of the material and information flow, that transform demand in to a product was created. In this section all the process activities will be drawn, and the value and non-value-added activities will be identified with a revised pragmatic future-state big picture map presented in section 5.1.3.2. The underpinning points provide a rationale for incorporating a big picture map during this research (Arnheiter & Maleyeff 2005):

1) The BPM helps to visualize more than one single process and facilitates the entire value chain to track the flow of materials and information.
2) Identify any waste in the value stream.
3) A low-level tool for decision making.
4) It acts like a blueprint for LEAN implementation.
5) It highlights any linkage between material and information flow.

5.1.1.4.1 TATA Steel Direct Supply BPM

In this exercise, two different BPM's was visualised during the group discussions held at Llanwern (Direct Supply) and Wednesfield (In-direct supply). The direct supply is illustrated in Figure 37. The customer service team of TATA Steel receives the delivery forecast from JLR on a weekly basis. The customer service team can access forecast data from 13-26 weeks. The minimum order quantities are verified at this stage by a

dedicated data transformation team at TATA steel. If the demand is <50% of the minimum order quantity, there is a manual process for transforming the data before it is sent to the central SAP. There are specific scheduling agreements in place for SKU routing and this is then checked and sent to the central SAP. Once the SAP processes the demand, a net planned order is sent to RAPID (data warehousing system). RAPID applies the yield rates and shifts the demand further to the OFID team. The OFID team convert the orders based on the ToC (colour coding) status of FG inventory, buffer stocks on the pipeline and the expected yields. The converted orders are then sent to the Factory Planner which creates a production plan before sending it to the scheduling team. This team sets an optimal sequence based on the first three days of the production plan. The production plan is based on asset, order and due date. The 3-day plan then is sent to BRONER where rules are set for sequencing. The BRONER based on a 3-day forward plan, transforms the sequenced production plan to MES (STACCA) and MES COMPASS for production. The automotive specifications are handled at ZODIAC. The FGs are then stored in an inventory holding centre with over 7-10 days of stocks. From this Inventory holding point, 10 -12 deliveries take place to shift the FG to the central “Armitts” Warehouse. JLR call’s off on a daily basis at Armitts and the call-offs are sent to the SAP to provide the information of the net planned orders and for billing.

5.1.1.4.2 TATA Steel In-Direct Supply BPM

As illustrated in Figure 38, the indirect supply deals with two or more warehouses. The Round Oak warehouse has a dedicated train link terminal to send four specific wide coils at a volume of around 200 Tonne per week to JLR-Castle Bromwich assembly plants. After the ZODIAC process line, a dedicated rail link which runs three times a day delivering coils and blanks. There are daily truck deliveries set to shift the coils from Round Oak warehouse to the Wednesfield warehouse. The demand process is initiated by two nodes: JLR Halewood and the JLR purchasing. The JLR Halewood specific SKUs are stored at “Armitts” and some SKUs are directly shipped in to the other plants like Castle Bromwich. The customer service team at Wednesfield receives daily call-off details of SKUs based on a 2-week horizon. The team creates a manual order based on the call-off and transform that demand information to the STRATIX

ERP. The manual orders translate the JLR specific SKU number to TATA part numbers and converts unit quantities of blanks to tonnage including any yield data. The JLR sends demand signals of other plants through a CMMS system (JLR's MRP system) with a 26-week planning horizon to the TATA Steel commercial department. They in turn transform that demand in to a spreadsheet every Friday evening before passing it to the central OFID team at Llanwern. The STRATIX ERP is a feed data like processing orders for the scheduling team at Wednesfield who takes the non-processing orders and load them onto lines. There is a one-week horizon for scheduling, and this is compiled in STRATIX from Wednesday onwards for the following week. The schedules are only made firm on a daily basis. The STRATIX also takes care of the non-scheduled requirements to replace any safety-stock in addition to managing the transport planning activities of wide coils on a daily basis to the Round Oak facility. One JLT batch quantity if every SKU call-off frequency varies from 1-4 weeks with an average cover of two week using the ToC BRAG code "B0012SS" indicating (Black = 0, Red = 0 Safety Stock, Amber 1 week > Safety Stock, Gren = 2 week > Safety Stock). The rest of production process is similar to the direct supply.

5.1.1.4.3 JLR BPM

The process in JLR with respect with TATA's product portfolio gets initiated after the pulling of stock takes place at "Armitts. A daily delivery mechanism is in place to pull the stocks to a holding area called "The Tent" closer to Halewood. At any given time, there are 3-4 days of stocks available at the Tent. The shears department takes hold of the daily stock situation and sends in advance shipment notice to the Armitts warehouse. The equality inspections take place at the tent and any stocks which are termed as defect will be sent back to Armitts. The quality verified stocks move up to the blanking or pressing facilities depending on the product specifications. There are 10 press machines at JLR which are functional. The blanking process is batched in consistent batch sizes of 1500-1700, with every batch made in eight days. The coil batches are based on frequency which is not set at the current time. After the blanking process, the stocks are again moved to an inventory holding area closer to the press shops. The delivery and dispatch process take place depending on the part's final destination. On the Information flow, the CMMS is the MRP system JLR uses for

demand management. The operation strategy in terms of the number of cars JLR is expected to produce a year is fed in to the CMMS and the system generates a rough estimate of the requirement based on that strategy. The Trim and B-I-W teams send their respective net requirements to the CMMS system that is updated every Saturday at 2 AM. The CMMS also takes responsibility of the safety stock with a set purchasing policy of 1-2 weeks of stock at any given time. The CMMS sets the batch sizes to set production requirements. The production planning and control team reviews the CMMS data on a daily basis and take an average of the Left Hand/Right Hand parts before setting the actual weekly requirements. The requirements are set on a rolling four-week basis and indicate at which location the material is required. The front-end of CMMS is visible to the customer service teams at TATA Steel and the entire planning process is based on this source of information. TATA steel is connected with the JLR purchasing team who in turn provides a 6-month forecasting prognosis for better planning practices. The entire summary of JLR's BPM is illustrated in Figure 39.

5.1.1.5 Preliminary Results of the BPM.

Summarising this section, the preliminary results of the BPM's will be presented below highlighting the core value stream issues that are present in TATA steel's supply management and JLR's demand management processes. The future state synchronised value chain will be presented in section 6.3.2

5.1.1.5.1 TATA Steel's process management based on BPM

Complex System Landscape

TATA steel uses a range of different ERP Systems with too many interfaces and handoff points. However, during the case study it was found that teams were using multiple standalone applications/tools based on Excel, developed by individuals. These tools according to the individuals were easier to handle that the existing SAP platform. However, the risk of losing that tool or individual in that department is huge.

Manual Creation of ERP orders

Despite analytical tools that are present in the wide scope of the organisation, major elements of ERP functionality are overridden by manual planning and order release. The replenishment orders are planned by reviewing excel spreadsheets that are developed by local departmental staff in isolation with the central ERP system.

Inventory Buffer

There is option within the inventory to indicate stock levels but not demand variability. The inventory buffers are in place with the "ToC" coding mechanism with manual replenishment planning aims to be "Top of Amber". The inventory buffers are not set and managed to fluctuate within the acceptable ranges to absorb the correct variability of demand.

Manual Adjust of Demand Signal

The demand transformation process is adjusted manually with the help of Excel macros that manipulate the incoming demand signal. The manipulation is performed for instance to facilitate batching of coil weight to overcome batching issues with the SAP planning parameters.

SAP Planning Parameters

The above-mentioned example of overcoming of batching issues is due to the SAP parameters inflexibility in triggering automatic replenishments is the coil weight is half the size of the batching rules set within SAP. There is an absence of a time fence in JLR or TATA causing any demand to trigger planned replenishment orders.

5.1.1.5.2 JLR's process management based on BPM

Demand Signals

There are two distinguishable demand signals handed to two different TATA Steel teams. Firstly, CMMS demand is communicated by JLR planning to TATA Steel Customer Service Team. Secondly, the press shop spreadsheet requirements are communicated by JLR press shop planning to OTIF department at TATA Steel

Batch Rules and Planning Parameters

There is no Fixed Order Quantities (FOQ) or Fixed order Cycles rule set in CMMS, prompting for immediate supply requirement on minor variabilities. CMMS output is not planned to make a production plan so independent excel sheets are sent to suppliers for four-week planning creating a distinct disconnect between the demand signal and the call-in procedure.

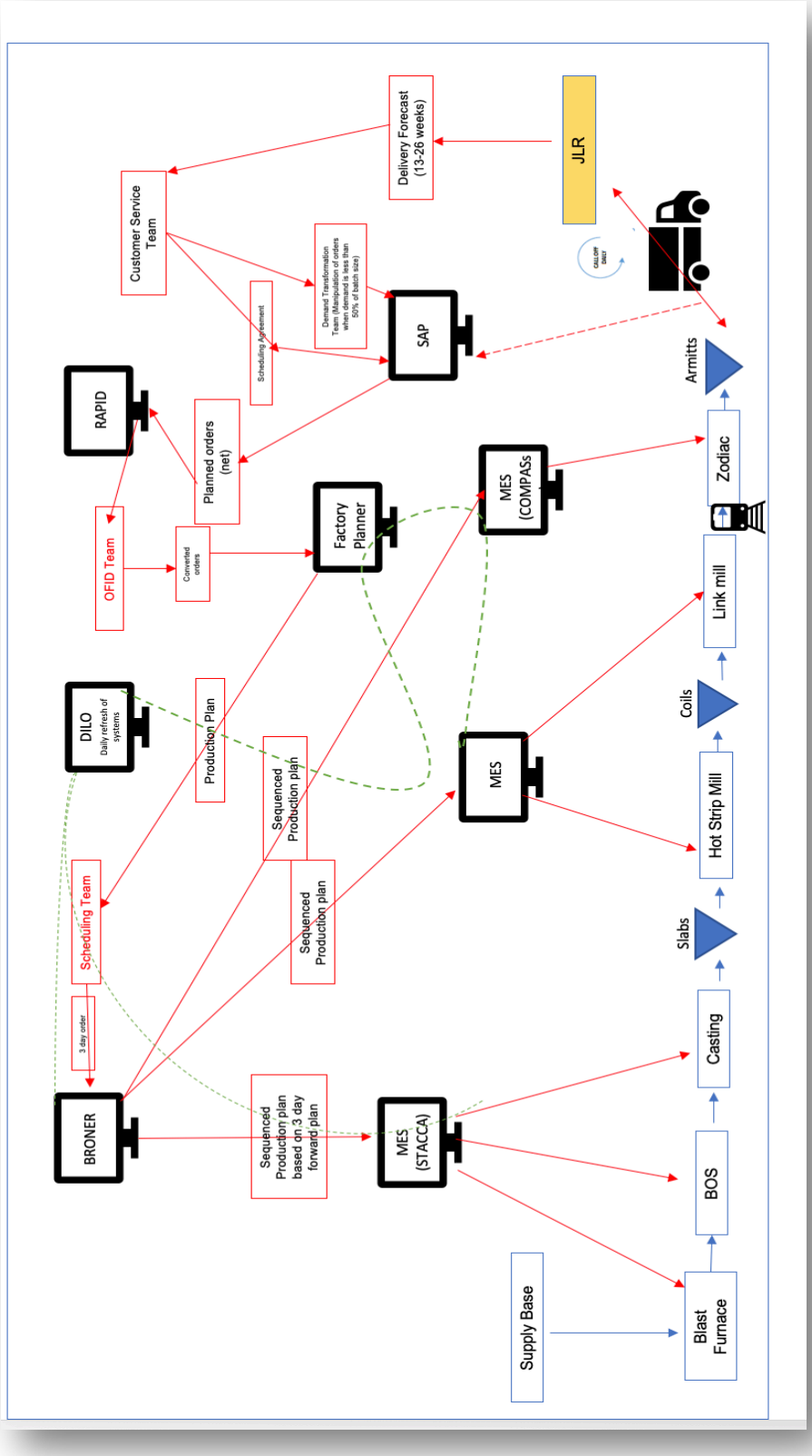

Figure 37: BPM Direct Supply TATA Steel (Source: WMG)

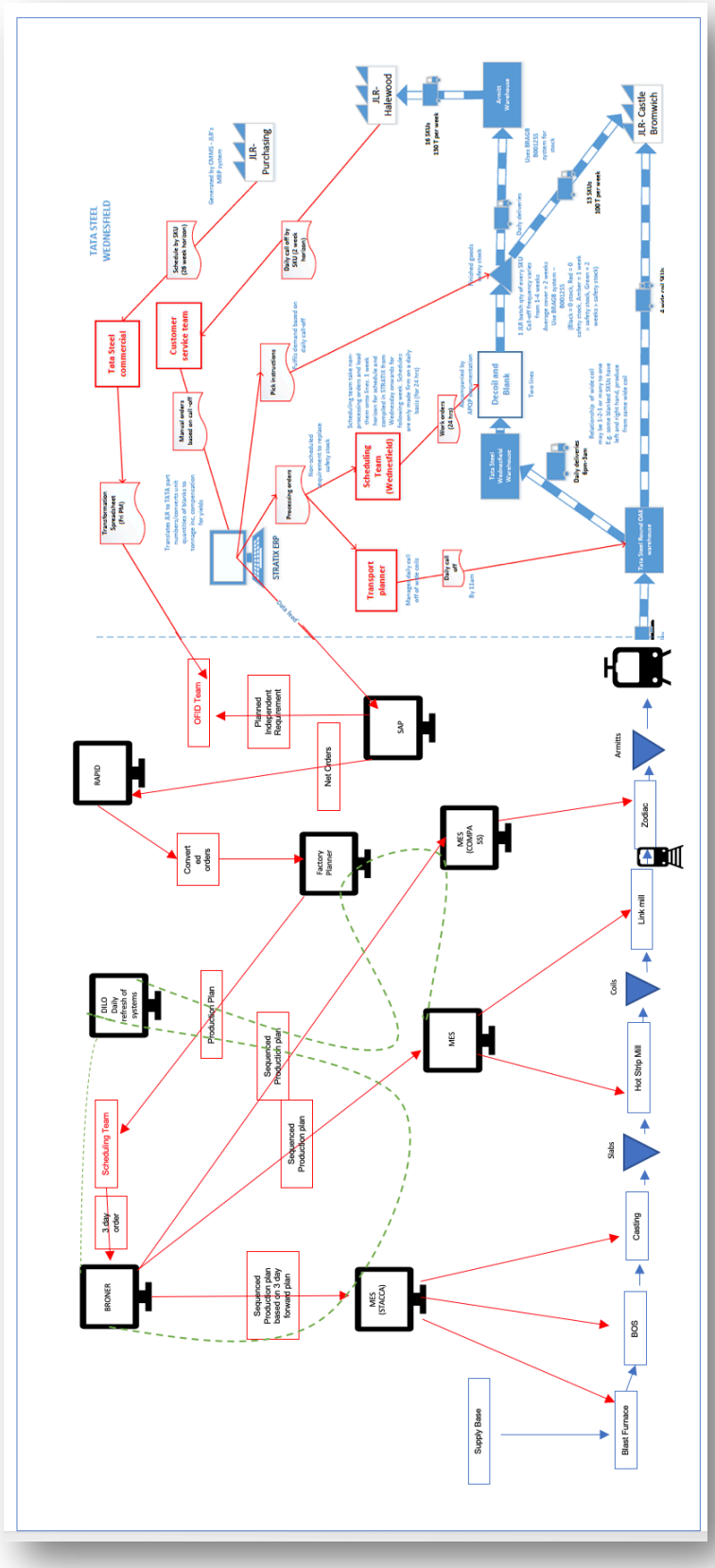

Figure 38: BPM in-Direct Supply TATA Steel (Source WMG)

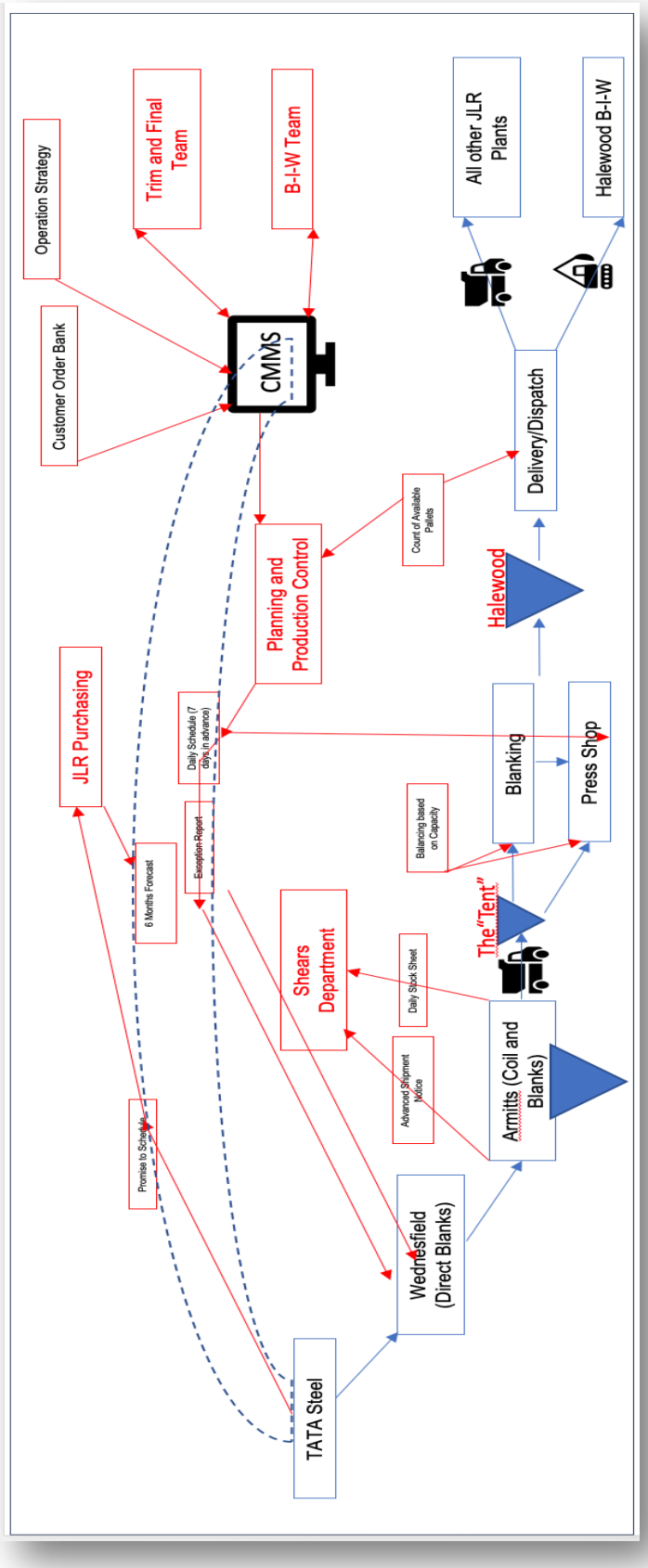

Figure 39: JLR's BPM (Source WMG)

5.1.1.6 Enabler & Inhibitor Analysis

Enablers and Inhibitors are a set of one's external beliefs about a specific system attribute that influence the user's perception of adoption or rejection (Cenfetelli 2004). The design and functionality of processes in companies involve a spectrum of many different states ranging from positive to negative ends. Enablers and Inhibitors are not opposite constructs but dual-factored ones (Cenfetelli 2004). It is common that different perceptions of system attributes exist, some of them perceive that the function or process is positive and some believe that it is negative (Bettman et al. 1998). The design and development of a process within a company is driven by an overall purpose to achieving positive perceptions of quality, in terms of information system or service (Hevner et al. 2004). However, negative attributes can arise by system errors or human influence. As explained throughout the course of this report, this study investigates complex, multidisciplinary teams at various levels of the organisation using different collaboration techniques and practices to drive the business. As the objective of these processes is to achieving better performance and better collaboration, it was important to study the human perception involved in the chain if some of the principles were beneficial with positive attributes or if it implicates business performance.

5.1.1.6.1 Context of the study

The E&I analysis aims to study the structures and processes with and between the different functions and members in the end-end value chain of TATA Steel and JLR. The objective of this study was to identify the key enablers and inhibitors between these two businesses and if there any implications that affect the business performance.

5.1.1.6.2 Design of the Survey Questionnaire.

The survey was based on the framework developed by (Wong et al. 2012). The framework identified and developed six enablers of alignment (Wong et al. 2012):

1) Organisational Structure (OS)
2) Internal Relational Behaviour (IR)
3) Customer Relational Behaviour (CR)
4) Top Management Support (TS)
5) Information Sharing (IS)
6) Business Performance Management System (BP)

There were four further inclusions of enablers by (Skipworth et al. 2015) namely:

1) Customer Alignment (CA)
2) Shareholder Agreement (SA)
3) Supply Chain Strategy
4) Business Performance Measurement (PM)

The definitions of these constructs are listed in Table 14 based on (Skipworth et al. 2015).

Table 14: Enabler Definitions based on Skipworth et.al 2015

Construct	Definition and measured items	Key references
Business performance (BP)	*Definition*: Financial performance of an organisation during the last five years *Measured items*: Net profits, revenue, market share and return on investment	Ahmed *et al.* (1996)
Customer alignment (CA)	*Definition*: Deliberate acts to achieve strategic fits in an organisation toward creating customer value *Measured items*: Consistency between business strategy and customer needs; extent to which performance of the supply chain/operations strategy fulfils customer needs; changes and adjustments of operations to fulfil different key customers' needs	Jaworski and Kohli (1993), Slater and Narver (1994)
Shareholder alignment (SA)	*Definition*: Business strategy, supply chain strategy and employees' expectations are aligned with shareholder objectives *Measured items*: Consistency between business strategy and shareholder objectives; consistency between operations/supply chain strategy and the business strategy; employees share same vision as shareholders; changes to process and organisation to deliver shareholder objectives	Lawrence and Lorsch (1967), Thompson (1967), Day and Fahey (1990)
Organisational structure (OS)	*Definition*: Process-oriented organisational structure with the ability to enable/support cross-functional knowledge exchange and inter-departmental activities *Measured items*: Scope of process control of SC/Operations Director, process owners, cross-functional process knowledge, involvement in inter-departmental activities	Ettlie and Reza (1992), Davenport (1993), Lewis and Slack (2003)
Internal relational behaviour (IR)	*Definition*: Activities and manners in which these activities are performed to facilitate the process of building up cross-functional relationships *Measured items*: Cross-functional activities; mutual understanding of other functions processes; joint problem-solving and planning across functions	Anderson and Narus (1990), O'Leary-Kelly and Flores (2002), Pagell (2004)
Customer relational behaviour (CR)	*Definition*: Customer interactions which facilitate the process of building up and maintaining customer relationships *Measured items*: Goal-sharing, cost sharing and profit-sharing practices with customers; and joint efforts with customers in problem-solving and planning	Day (1994), Auramo *et al.* (2004), Tracey *et al.* (2005)
Top management support (TS)	*Definition*: Support and commitment from top management in supply chain management *Measured items*: Listens to employees on SC issues; participation in supply chain meetings; provides human resources and capital investment for SC initiatives; emphasises strategic importance of supply chain management; aware of need for supply chain capability to meet customer needs	Gerbing *et al.* (1994); Ahire *et al.* (1996); Buhner (1997); Storey *et al.* (2005)
Information sharing (IS)	*Definition*: Sharing of information for facilitating business strategy and supply chain activities *Measured items*: Sharing relevant, accurate and sufficient information for operations/ supply chain in a timely manner and level of knowledge required to use available information	Bourland *et al.* (1996); Lee and Whang (2000); Sahin and Robinson, (2002); Li *et al.* (2005)
Business performance measurement system (PM)	*Definition*: The system in which business performance is being measured and utilised for achieving the improvement *Measured items*: Links between strategic objectives and performance targets; performance is reported and reviewed against targets at agreed intervals; performance measurements are used for process optimisation across functions	Schmenner and Vollmann (1994), Gunasekaran *et al.* (2001)

The survey was divided in 10 blocks or topics with six questions in one topic, five questions for three topics and four questions for the rest of the topics. The questions range from 1 to 7: 1 denoting to “Not at all” and 7 denoting to “Very Strongly”. The values were summed up from all the respondents and taken a mean value. The mean values were then depicted in a radar chart with the axis value of 0 to 5, where 0 represents “Not at all” and 5 represents “Very Strongly”. The response rate was 91% from TATA Steel and 66% from JLR. The questionnaire was coded using the Qualtrics Survey tool and distributed via a confidential link to the respective people within various departments across the companies. The roles of the people who participated in this study are listed in Table 15. The questionnaire with the respondent results is annexed in the appendix of this report. Due to the ethical implications, all responses were anonymised. The survey was open for a two-month period, it takes 15 minutes to complete the survey.

Table 15: Roles of personnel targeted in the Survey.

Department	TATA Steel	JLR
Supply Chain	Director of SC	Head of Supply chain
Customer Service	Customer service managers	Customer service managers
Demand	Demand Planners	Demand Planners
Planning	Process lead teams	Process Lead teams

5.1.1.7 Preliminary Results of the E&I Analysis

This section will cover the results of the individual enablers as listed below. In considerations with the context of the study, six enablers were chosen to study: Organisational Structure, Internal Relationship Behaviour, Customer Relationship Behaviour, Information Sharing, Top Management Support and Performance Measure Systems. The identified enablers and inhibitors are presented in Table 14 and Table 15. The actions to turn the inhibitors to enablers are presented in chapter 6.3.3.

5.1.1.7.1 Organisation Structure

This section highlights the cross-functional knowledge exchange and inter-departmental activities taking place within the company. This block was measured based on the attributes listed below:

1) The control operations for the core business processes (Plan, Source, Make, Delivery and Sales) of the SC director.
2) Process owners for each of the core business processes
3) Cross-functional knowledge and skills within the company
4) Department organised according to the core business processes
5) Interdepartmental activities

In the radar chart displayed in Figure 40, it is evident that the TATA Steel's SC director has more business processes in control than the JLR's management. Both TATA Steel and JLR' pattern is identical on process ownership and both companies are driven by processes.

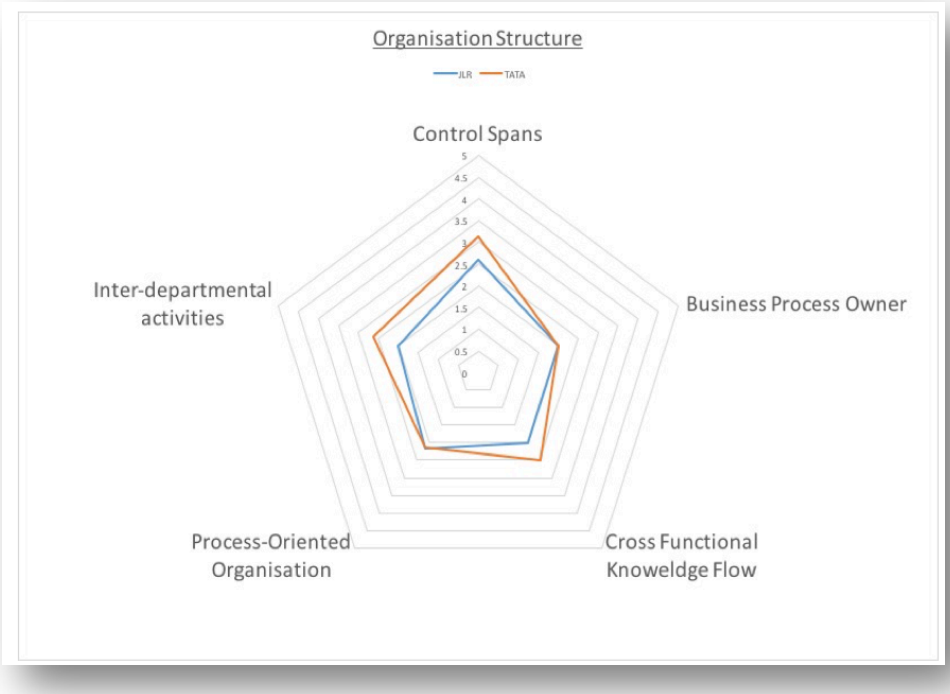

Figure 40: Organisation Structure

In the cross-functional knowledge and skills required to manage the core business processes, TATA steel exhibits a slight improvement over its customer JLR. However, on analysing the pattern of this entire block, both the companies can be benefitted on any changes made on a process level as they both exhibit a strong culture driven by processes.

5.1.1.7.2 Internal Relationship Behaviour

This section highlights on the internal activities the company indulge to facilitate the process of cross-functional relationship. This internal relationship behaviour metric is measured using some these attributes listed below:

1) Employee involvement in cross-functional activities
2) Current level of mutual understanding in terms of business processes
3) Joint planning and problem-solving practices

As illustrated in the Figure 41, the team within the companies showcase a consolidated

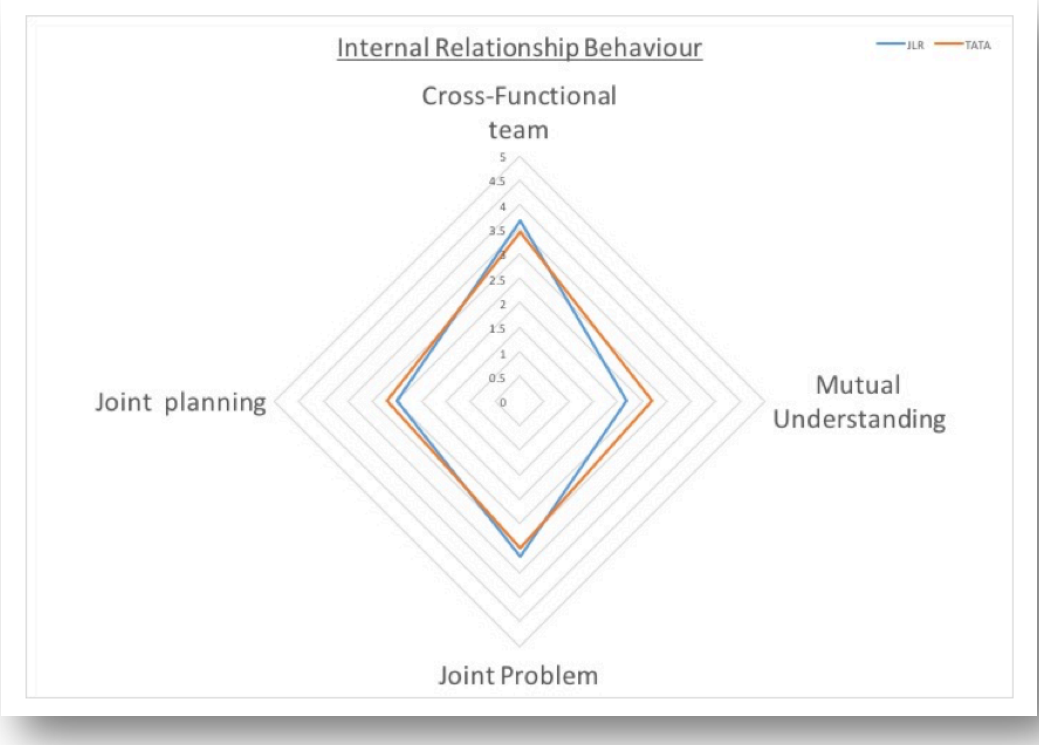

Figure 41: Internal Relationship Behaviour

pattern of cross-functional team work with most functional departments are willing to plan and solve problems together for the core business processes. They in addition, also exhibit a good understanding of each other's business processes. Overall, the internal relationship behaviour of both the companies highlights professional behaviour and willingness to jointly plan and solve problems.

5.1.1.7.3 Customer Relational Behaviour

As end-end planning requires strong, dedicated customer relational behaviour, this section is crucial for this research. The customer relationship behaviour was measured with the metrics of goal and cost sharing practices along with the joint problem-solving and planning practices between the two companies. The attributes are listed below:

1) Goal Sharing Practices
2) Cost Sharing Practices
3) Joint Problem-Solving Practices
4) Joint Planning Practices
5) Profit Sharing Practices

Figure 42: Customer Relationship Behaviour

As illustrated in Figure 42, it is evident that JLR's customer relationship behaviour strategy and practices are better than JLR's practices. The companies have a do highlight some cost sharing practices, but it is not evident if the cost is shared with only a key customer with most of the key customers. However, TATA steel is keen to share its goal to the JLR with more commitment in joint-planning and joint-problem solving practices.

5.1.1.7.4 Top Management Support

The metrics used to analyse the support of the top management are:

1) Listening to issues on core SC issues
2) Participation in SC meetings
3) Investment in HR and other resources
4) Level of strategic involvement in SC management
5) Awareness of needs and capability

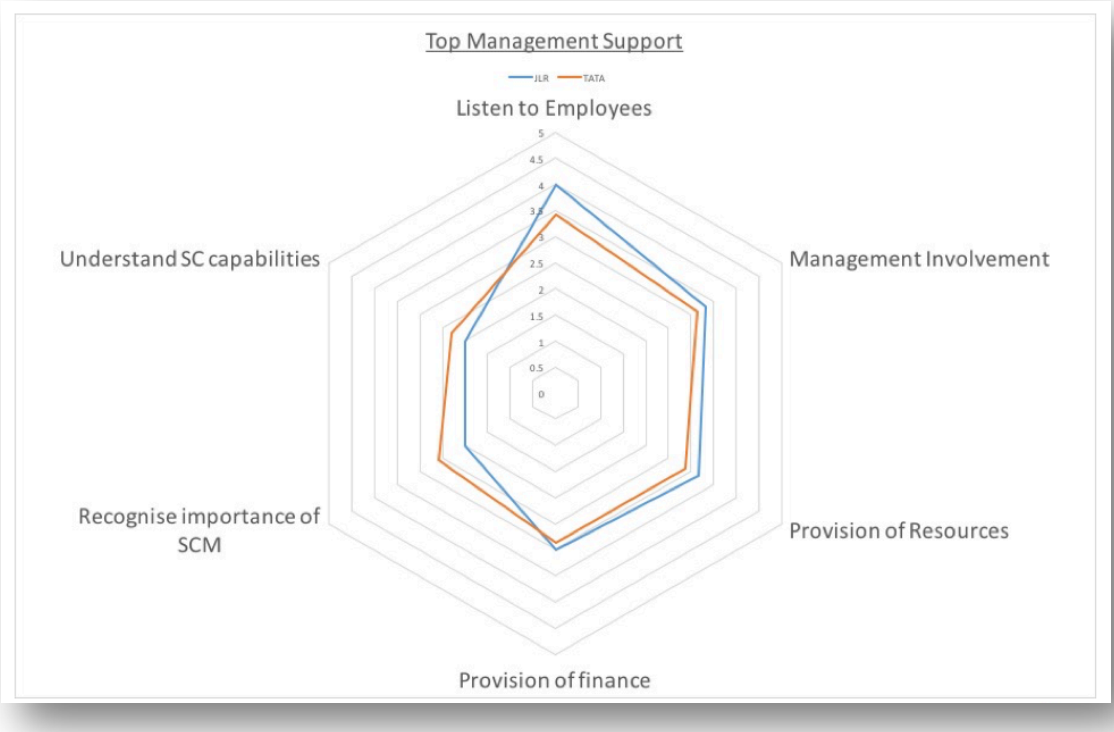

Figure 43: Top Management Support

In the result of the analysis displayed in Figure 43, it is clearly evident JLR's top management listen more to its employees and have a slightly positive trend in provision of HR and other capital investments. However, both top managers in the company have lesser SC capabilities and minimal strategic involvement. Even though they participate in regular meetings, they infrequently read the reports generated by the technical teams.

5.1.1.7.5 Information Sharing

In this section, it was essential to evaluate if the information sharing was accurate, sufficient and in a timely manner. The metrics used to analyse the information sharing aspect of the collaboration are listed below:

1) Sharing relevant information
2) Sharing accurate information
3) Sharing sufficient information
4) Timely sharing of information
5) Knowledge to use the shared information.

The Figure 44 highlights that there is a big gap between companies on the aspect of sharing relevant information. The information available to the SC department seems to be relevant to the management of the material flow. However, there are no signs that the accuracy of the information in terms of the material flow despite the information being shared in timely manner. Both the companies have identical pattern in displaying lower level of knowledge to use the available information.

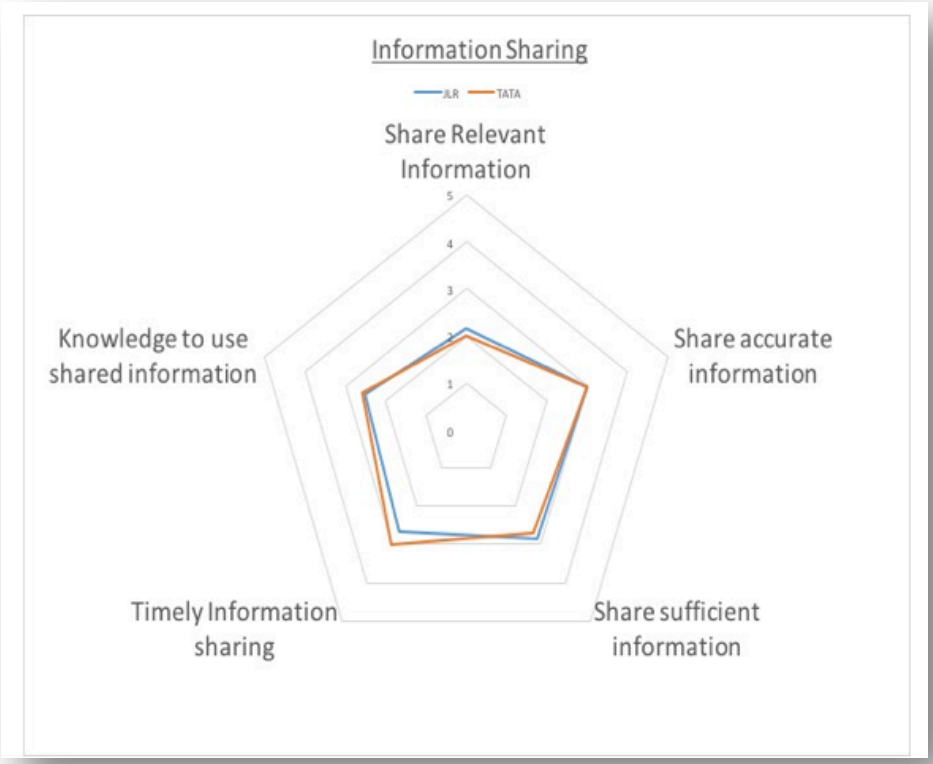

Figure 44: Information Sharing

5.1.1.7.6 Business Performance Measure Systems

The core links between the strategic objectives and performance targets were reviewed in this section. It was seen if performance measures were used process optimisation across the functions. The key metrics for this section:

1) Strategic Objectives
2) Timely Reporting
3) Shared Incentives and rewards
4) Shared performance metrics.

In Figure, 45, it is evident that the performance targets at both companies at different organisation levels are slightly linked to the overall business objectives of the company and in most cases, reviewed and reported at agreed intervals set by the management.

However, when the performance targets are not met, the companies make minimal action to improve the performance.

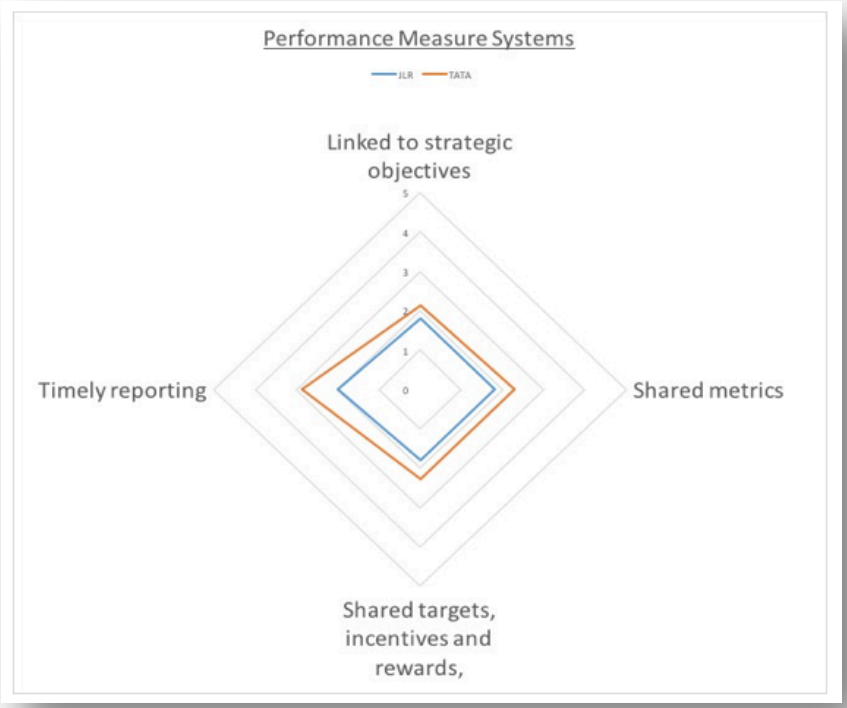

Figure 45: Business Performance Measurements

5.1.1.8 Key Enablers

The key Enablers identified during this analysis are listed in Table 16.

Table 16: Key Enablers

No	Enabler	Explanation
1	Cross functional team	Both companies exhibit good internal planning and problem-solving capabilities.
2	Feedback Mechanism	The top management is keen to listen and are actively involved with employees.
3	Reporting Mechanism	There is an active reporting mechanism in place and the supplier is keen in enhancing this method.
4	Business Strategy	The business strategies of the two companies are highly customer focused.

5.1.1.9 Key Inhibitors

The key inhibitors identified during this analysis are listed in Table 17.

Table 17: Key Inhibitors

No	Inhibitor	Explanation
1	Joint Planning Activities	Despite highlighting a positive trend in internal planning, there is a definite need for joint planning and problem-solving practices between two companies
2	Sharing Information	Both companies are in the need to develop new mechanisms to share relevant, accurate and sufficient information in a timely manner
3	Provision of Resources	The top management of both the companies are currently reluctant to provide the necessary financial resources, as they do not recognize the important of Supply Chain Management activities
4	Change Management	There is a negative trend on both companies in implementing any change or adjusting the needs of the customer.

5.1.2 Segmentation Analysis

The data used to perform the analysis were gathered from three sources as explained in Table 16. The planning practice details of TATA Steel and JLR were highlighted in Chapter 5.1.1.1 a quick summary of the current planning practice is illustrated in Table 18 with the data sources displayed in Table 19.

Table 18: Current Planning Practices and Data Source

Category	Current Practices
Owner of demand	Customer Service Team Llanwern, Wednesfield Planning Team.
Manufacturing Strategy	MTA / MTF (50% - 50%)
Forecasting Techniques	6-month historical data + 6 month ahead from JLR purchasing team
Current SC Segmentation	ABC Classification on Inventory
Inventory Ownership	• Llanwern • Wednesfield • RoundOak • Armitts • The Tent • Halewood

Table 19: Data Sources

Data No	Source	Detail
1	Round Oak	No of Pieces and Weight
2	Wednesfield	• Weekly Deliveries • Call-off • Forecast
3	Blanks supplied in to Halewood	• Weekly Receipts • 4 Week Demand • Daily Stock in Armitts • CMMS weekly stock level

5.1.2.1 Scope of Segmentation

The scope of the project was limited only to the In-direct supply from Wednesfield. Hence, the analysis is limited to the 22 blanks delivered from Wednesfield to “Armitts” and 9 blanks that are dispatched directly to the "Tent”. The data requirements for performing the segmentation analysis were:

- Inventory at Round Oak for the past year at part level
- Inventory at Wednesfield for the past year at part level
- Planned process/ pick orders created by Wednesfield in response to the call off
- Scheduled process orders created by Wednesfield
- Actual production orders which are finally executed against Demand signal sent to Llanwern Zodiac from Wednesfield/Round Oak
- Actual orders placed on Llanwern Zodiac from Wednesfield / Round Oak
- Actual delivery into Round Oak from Llanwern

5.1.2.2 Data Feed Specification and Assumptions

The researcher received nine different sets of data including actual production, forecast, stock level and planned production data. As this research is novel in terms of segmentation from an end-end value chain, the data sources were received from both companies. However, the data was limited only for 26 weeks due to new system considerations at JLR. The initial task was to separate the blanks part from the entire data set which involved all products from all customers. After validating the SKU part numbers with the JLR part numbers, a daily stock set was extracted along with a daily consumption set. The next step was to collect the weekly forecast data of the corresponding parts and the actual receipt in to Halewood in correlation to the forecast and production planning data. The basic assumptions were that the stock flow data that is tagged as non-Armitt's stored parts are delivered direct to Halewood from Wednesfield. The analysis as illustrated in Figure 46 is applied, based on the four-stage research design as proposed by (Godsell et al. 2011).

5.1.2.3 Segmentation Process

In the fourth portfolio submission "Innovation Framework", a detailed analysis based on literature was conducted to explain the motives behind the demand profiling approach for this study. This included explanation of the six methods which were used in this research:

1) Volume Analysis
2) Demand profiling and Demand profiling (Syntetos et al. 2004, Kharlamov et al. 2015))
3) Volume Throughput Analysis (ABC Analysis Runner, Repeater and Stranger)
4) Inventory Policy.

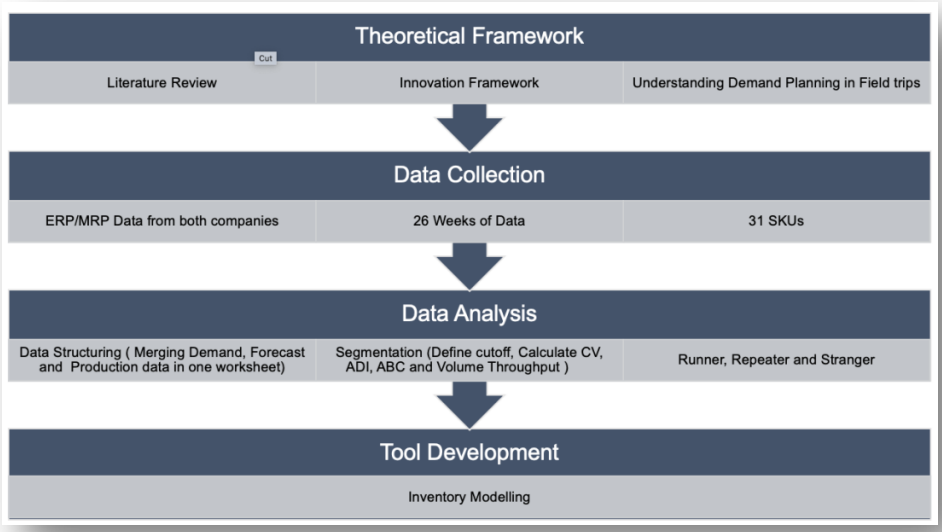

Figure 46: Four Stage Research Design (Source adapted after Godsell 2011)

As illustrated in the Figure 47, A volume analysis was conducted to analyse the consumption details of the SKUs. This facilitates the item class determination where the SKUs based on their consumption, are spilt into ABC categories. In the segmentation process the seasonality of the demand is normally removed using the demand decomposition method before merging the demand profile data to perform the ABC analysis. The CV threshold values were set to 40% for the order size variability and 50% for the order frequency variability (Godsell et al. 2011). This compares the coefficient of variation in order size to the coefficient of variation in weeks between orders. Finally, the volume-throughput analysis is conducted to identify the Runners, Repeaters and Strangers.

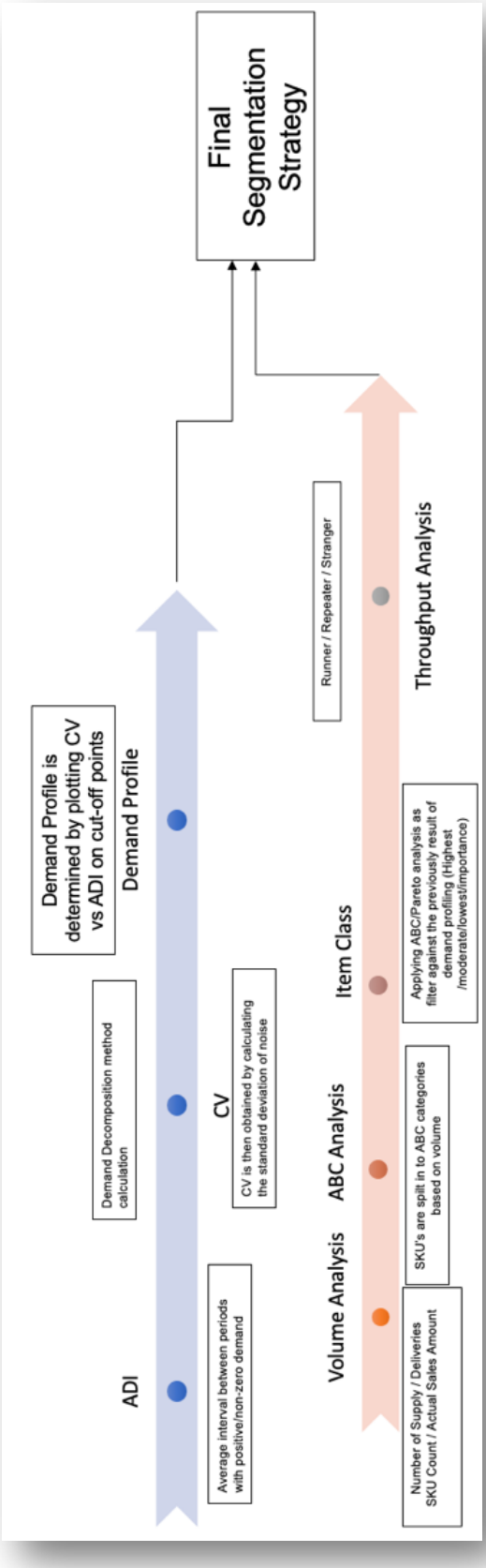

Figure 47: Segmentation Process

5.1.2.3.1 Volume Analysis

Figure 48 highlights the volume analysis based on the actual sales data and the Figure 49 shows the monthly consumption data of all the SKUs. 18 blanks make up 80% of actual sales volume with 8 blanks make up 52% of sales. The rest of the 12 blanks, account to the 20% of volume.

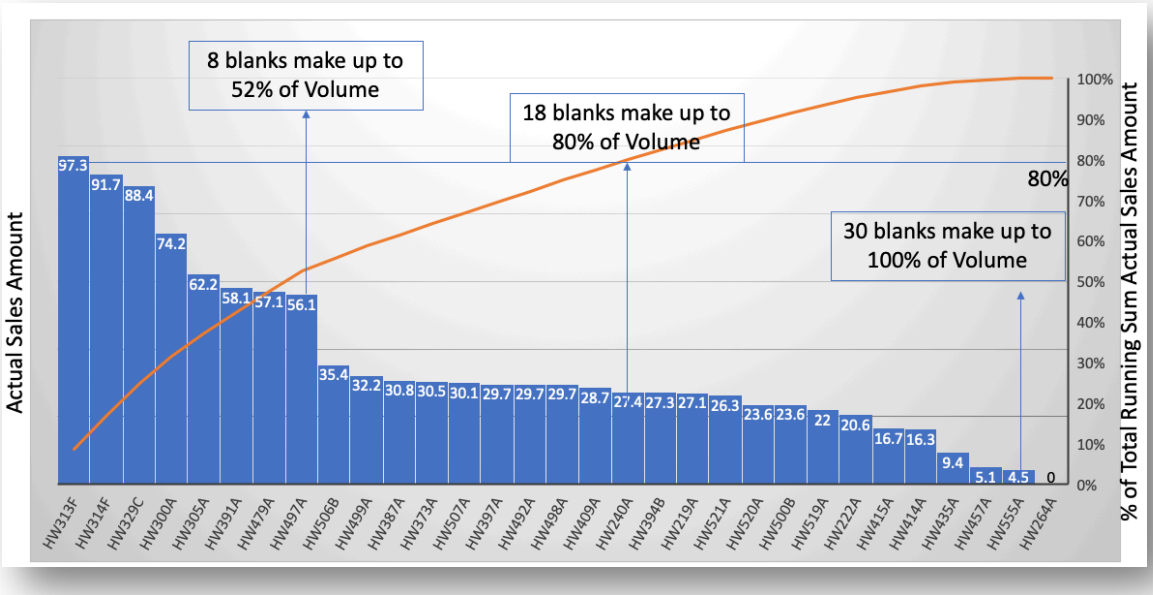

Figure 48: Volume Analysis based on Actual Sales Consumption

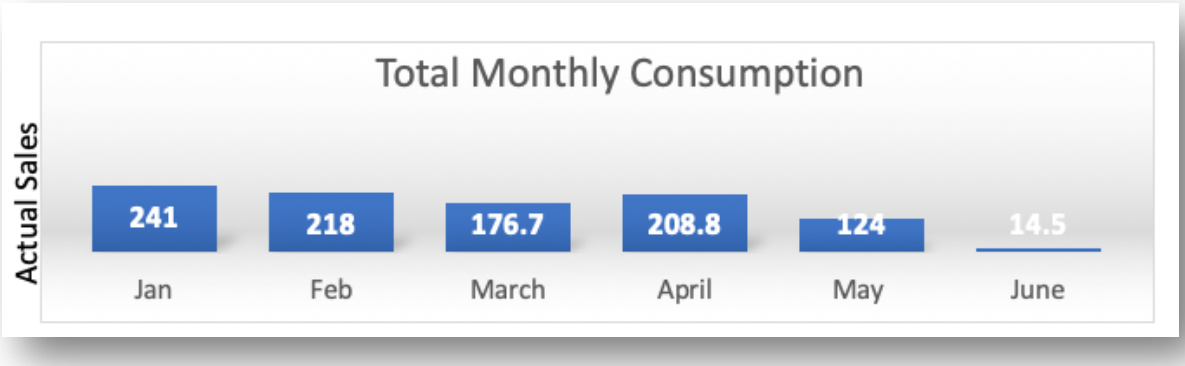

Figure 49: Total Monthly Consumption

5.1.2.3.2 Demand Profiling

In this research scenario, the demand profile was determined by plotting the coefficient variation of the sales amount (CV) vs the average order frequency variability (ADI) on

pre-determined cut-off values such as 40% for CV and 50% for ADI. The demand profiling results of the 31 SKUs are illustrated in Figure 50.

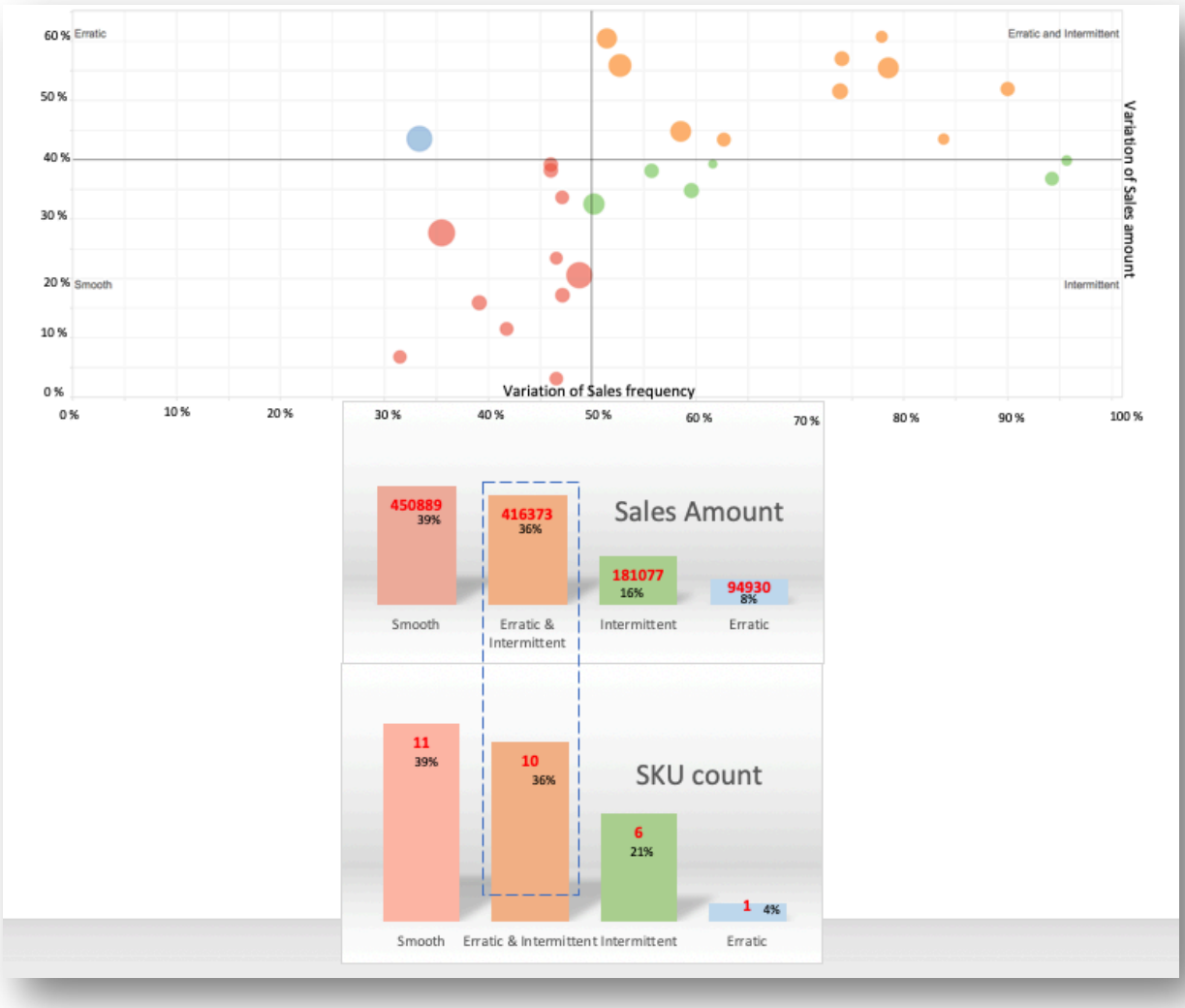

Figure 50: Demand Profiling of the 31 SKUs

The segmentation results indicate that 10 SKUs, representing 36% of total volume exhibit erratic and intermittent demand profiles. It is also evident in Figure 51 that high volume SKUs that account to 80% of total volume showcase different demand profiles. On analysing the high-volume SKUs, the order frequency variation and order size variation is identified as presented in Table 20. In total, 11 SKUs exhibited smooth profiles, 10 Erratic & Intermittent, 6 Intermittent and 1 erratic profile.

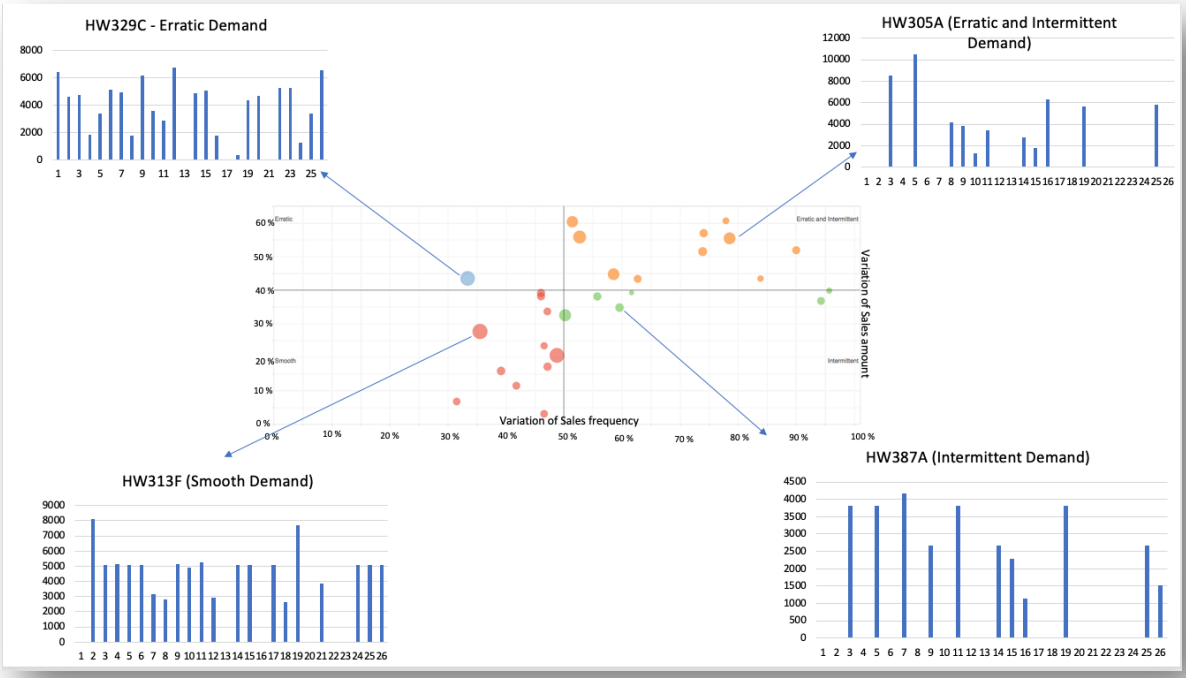

Figure 51: High Volume Demand Profiling

Table 20: Example of Size Variability and Frequency variability

SKU No	Type	Volume	Size Variability	Frequency Variability
HW329C	Erratic	88K	43%	33%
HW313F	Smooth	97K	28%	36%
HW305A	Erratic & Intermittent	62K	55%	79%
HW387A	Intermittent	31K	35%	60%

In the next step of the analysis, the forecast accuracy of the high volume, smooth segments SKUs were identified. It is be noted as displayed in Figure 52 that even for the high-volume smooth segments, the forecast accuracy was poor. The forecast variability was in between from 58% to 270% from the actual sales data.

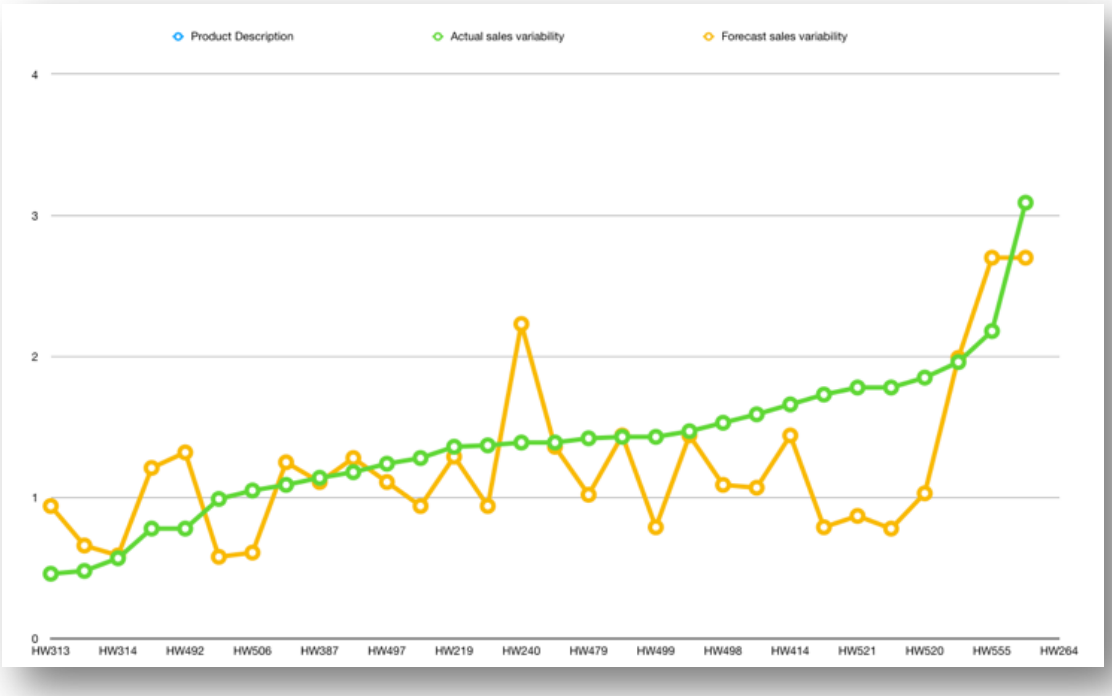

Figure 52: Forecast Variation

The focus shifted on analysing the replenishment policy in order to calculate the reliability of production and the frequency of production. The subset of SKUs chosen were the ones with high volume, smooth demand profiles vs the high value erratic and intermittent segments. In Figure 53, the smooth profile highlights a consistent weekly delivery throughput pattern. However, as shown in Figure 54, with the erratic and intermittent demand segment, the replenishment policy is in-consistent.

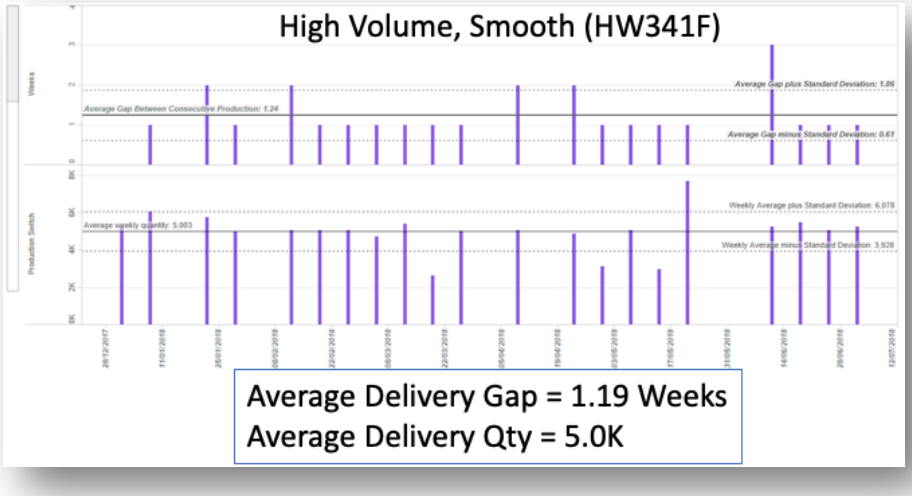

Figure 53: Replenishment Plan for Smooth Profiles

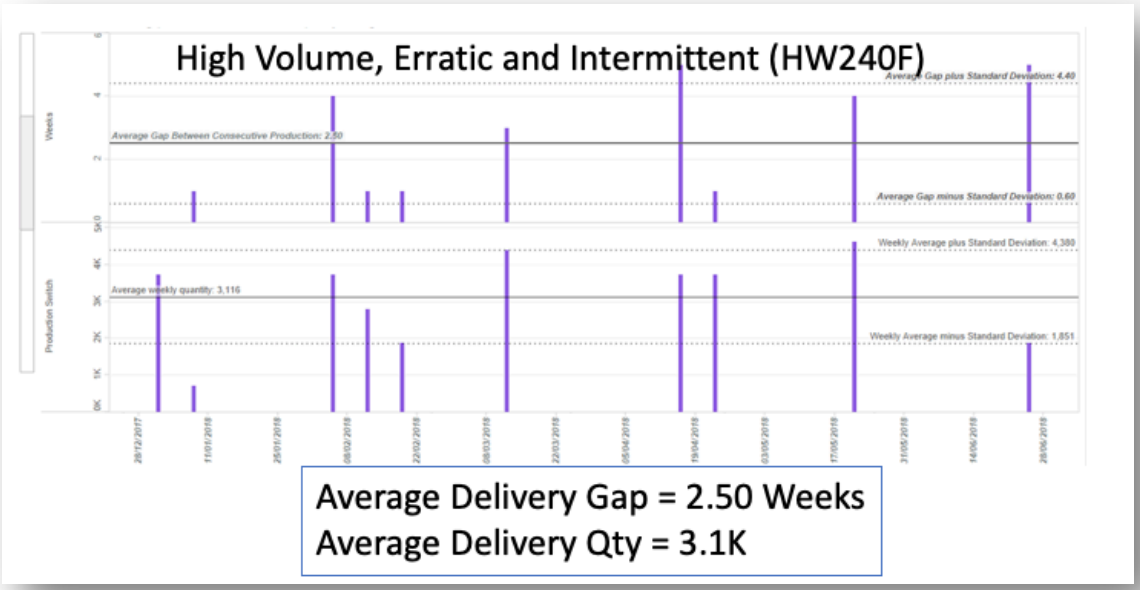

Figure 54: Replenishment Plan for Erratic and Intermittent Profiles

5.1.2.3.3 Item Class Definition

An "ABC" filter is applied against the demand profiling results to determine the Item class of the SKUs. The SKUs are spilt in the ABC categories based on the sales value as shown in Table 21.

Table 21: ABC Analysis

	Number of SKUs		Value		Volume (KT)	
Class	**Amount**	**Amount %**	**Amount**	**Amount %**	**Amount**	**Amount %**
A	18	60%	400230	80%	889.44	80%
B	6	20%	75015	15%	166.77	15%
C	6	20%	25110	5%	55.88	5%

In the ABC analysis as listed in Table 22, the results suggest that an ideal Pareto value is translated in terms of volume. It is evident that 60% of SKUs contribute to 80% of volume and value and the rest of SKUs contribute to the 20% of value and volume. In the next step, the principles of the ABC analysis and the demand profiles of the individual SKUs are combined to create a 9-Box Plot to distinguish the SKU in a differentiated item class as displayed in Table 20. This differentiated class is used to determine specific target service levels for every SKU which then will be used in

calculating the inventory. This is explained in section 5.1.2.6. The differentiated classes are listed in the colour code as listed below:

1) Class 1 – Highest Strategic Importance - 99.5% of Service Level
2) Class 2 – Moderate Strategic Importance – 95% of Service Level
3) Class 3 – Lowest Strategic Importance – 90% Service Level

The percentage of total sales and the percentage of total products in context to the segmented profile is highlighted in Table 23. There were 2 SKUs which are classified as "Undefined" as they registered only one sale in the entire 24 weeks of data, which meant that the CV was not calculated.

Table 22: Item Class Differentiation

Sales Value	Smooth	Erratic	Intermittent	Erratic & Intermittent	Undefined	Total
A	6	1	3	8		18
B	5	0	1	0		6
C	0		2	2	2	6
Total	11	3	6	10	2	30

Table 23: Sales Value of Segments

Class	No of SKUs	Demand Type	% of Total Sales	% of Total Products
A	8	Erratic & Intermittent	32.72	25.8
A	1	Erratic	8.23	3.2
A	3	Intermittent	10.9	9.7
A	6	Smooth	27.87	19.4
B	1	Intermittent	2.36	3.2
B	5	Smooth	11.21	16.2
C	2	Erratic & Intermittent	3.37	6.5
C	2	Intermittent	2.43	6.5
NA	2		0.89	9.7
TOTAL	30		100%	100%

5.1.2.3.4 Volume Throughput Analysis

As illustrated in Table 24, the RRS (Runner, Repeater and Stranger) analysis in this case was based on the weekly threshold average of the throughput. Items are classified as “Runners” if the variance, is < 100% of products that are ordered in > 80 % of the weeks. The “Repeaters” are classified as item with variance of < 200% of products that are ordered in > 30% of weeks. The “Strangers” have a variance of 200% or if is ordered in < 30% of weeks.

Table 24: Characteristics of RRS

Type	Characteristics	Criteria
Runner	Regular Usage with minimal fluctuation, stable and predictable demand pattern	- Variance < 100 % - Ordered in > 80% of weeks
Repeater	Slightly irregular usage with some fluctuation, predictable(reasonably) demand	- Variance < 200% - Ordered in > 30% of weeks
Strangers	Erratic and extremely irregular usage with heavy fluctuation and unpredictable demand	- Variance > 200% - Ordered in < 30% of weeks

The sales pattern of a runner, repeater and stranger SKU is displayed in Figure 55. The complete list of the SKUs’ with RRS classifications are attached in the appendices.

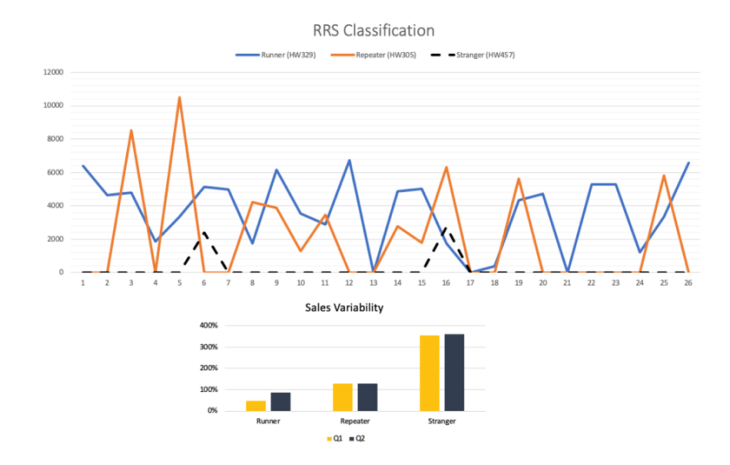

Figure 55: Examples of RRS

The combination of ABC-RRS analysis provides a segmentation principle that can serve as a prerequisite for cost efficient inventory design. The ABC-RRS product segmentation provides a rational platform for selection of products for which the stocks could be designed based on the results of the segmentation. An annual replenishment or a VMI-repeater strategy is suggested in the first case if the lead time is not known for the for this classification of the products. If the lead-time can be identified, then the SKUs can be listed as strangers. In the first model, all the segments will qualify for inventory design but in the case of the strangers, the SKUS will not be hold at Armitts as on firm orders, the delivery will be made on promise without any holding stocks. However, in the case of the VMI-repeaters, the frequency of replenishment along with the volume of sales will be based on the actual physical stock at Armitts in consideration with the actual demand. The researcher altered the original innovation framework in to two models in contrary to a single model proposed in chapter 3.1 by replacing the stranger SKUs to VMI-repeater SKUs in consideration of the lead times for the low volume SKUs being critical for production. The proposed VMI-repeaters are based on automatic VMI type replenishment with the actual demand. The replenishment cycle and order quantity can be determined by the monthly consumption average and despite there is some inventory available at Armitts, the stock levels are placed in the inventory for continual production (no production stoppage) and attaining higher customer service levels. The final segmentation results as listed in Figure 56 suggests that 10% of “VMI-repeaters/Stranger” SKUs represents only 2 % of volume and value, while 17% of “Runners” is equivalent to 32% of volume and value. The repeaters represent 73% of SKUs with a value of 66%. The segmentation results are presented in Figure 57.

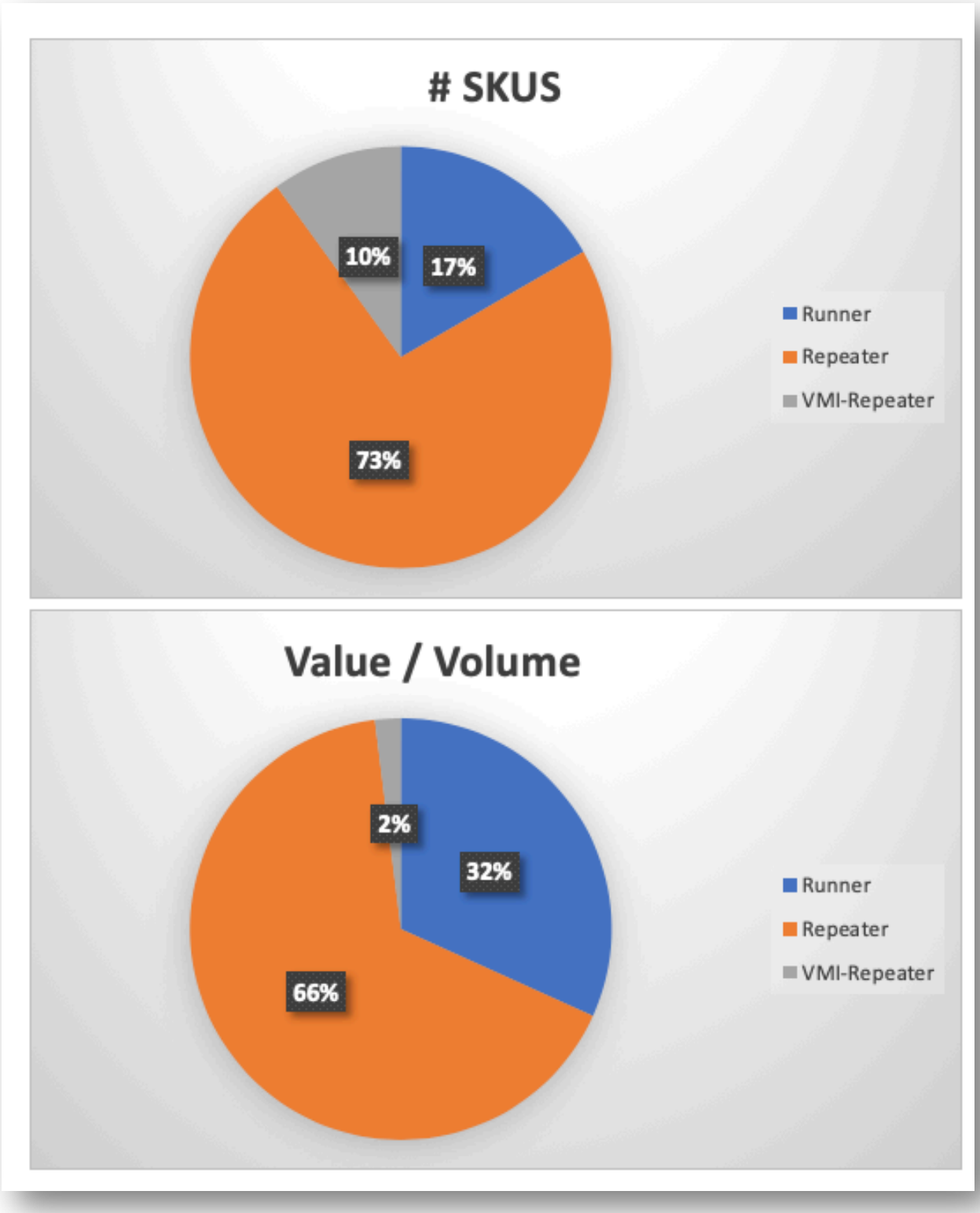

Figure 56: Volume-Value

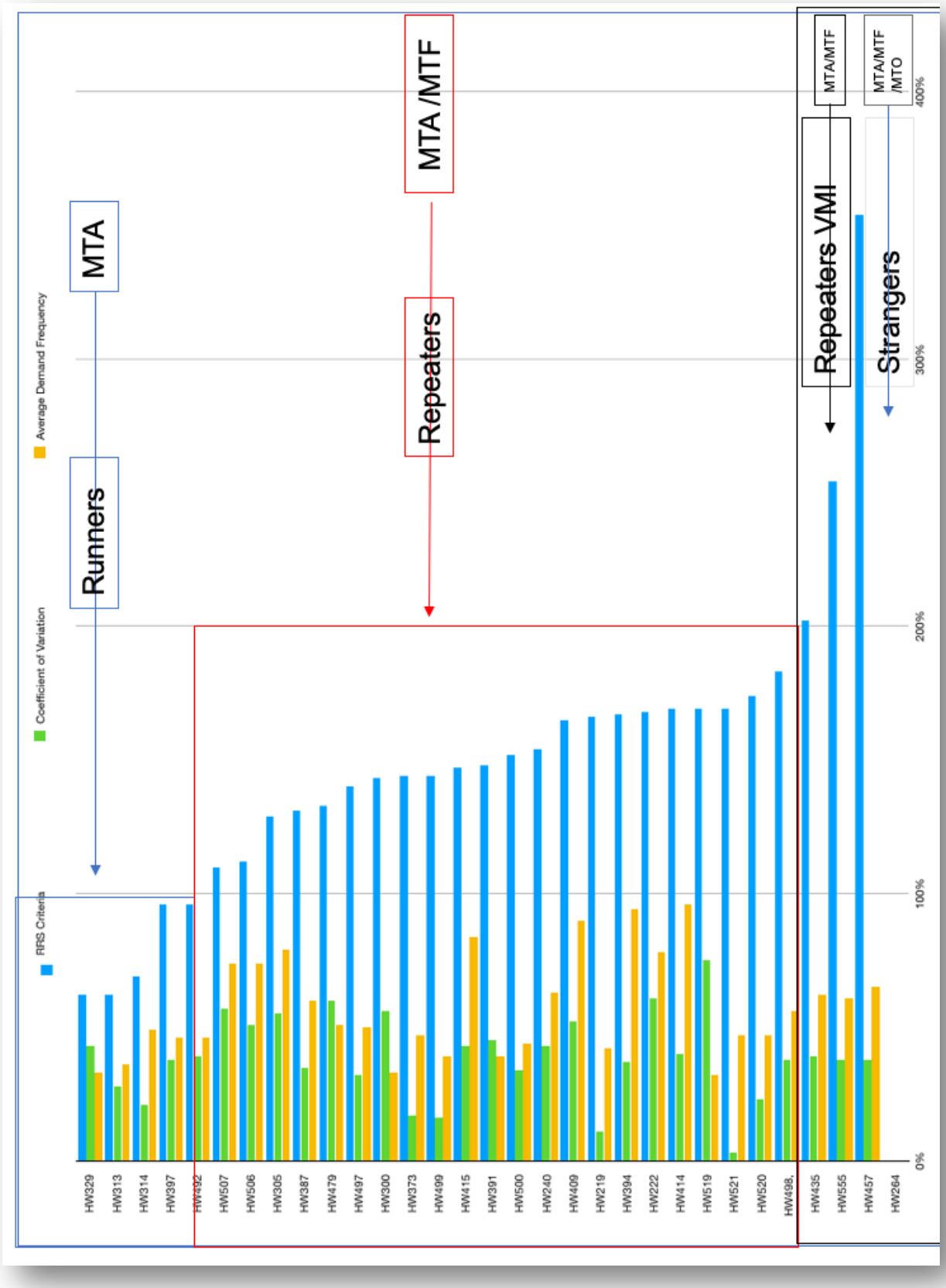

Figure 57: Segmentation Results

5.1.2.4 Updated Innovation Framework based on Segmentation Results

The researcher is proposing two frameworks that can be used by the companies. The rationale behind developing two frameworks is that the lead-time for some of the stranger SKUs are not known at this point of analysis due to the data constraints. The first model assumes that the lead-time of stranger SKUs is not known as shown in Figure 58. Both the models are identical in terms with the runners and repeaters, for instance the MTA strategy is designed for the runner SKUs. The demand signals are processed within the manufacturing order chain of the supplier and the FGs are ready for direct dispatch from Armitts to the Halewood plant, as there is a continuous requirement. There is a minimal holding of stocks at Armitts and the entire demand management is based on actual consumption. The repeater SKUs for both the models is designed for MTA/MTF strategies. The demand is forecasted in this strategy, and the FG's are ready for dispatch based on the forecasting schedule. All the SKUs use Armitts as a central inventory in the first model whilst the VMI-repeater strategy is based on the replenishment frequency at Armitts and on - real time demand. As shown in the second model (Figure 59, the manufacturing strategy can be assigned as MTO with no stocks in inventory for this classification of the SKUs with the delivery method based on the firm orders from JLR, with the lead-time of the product. In this integrated planning scenario, the stocks are monitored in a continuous basis based on actual consumption, allowing the order to be placed automatically when the set re-order point is reached. In the current scenario, the planning autonomy is curtailed due to poor demand management techniques. As in the suggested integrated planning system, a higher SC visibility in terms of demand planning is attained and as the variability of demand is managed by classification of segments (runners, repeaters, strangers and repeater-VMI). The emphasis of the research was in managing demand and not minimising fluctuations of the demand and by applying this framework, TATA Steel can manage the JLR's demand individually for the identified SKUs based on the segmentation results. In the context of this integrated planning, by introducing 'Fixed Order Cycle methods', significant benefits for joint replenishment orders can be achieved with significant lower costs. The quantifiable benefits of such a framework will be presented in the inventory modelling section 5.1.2.6.

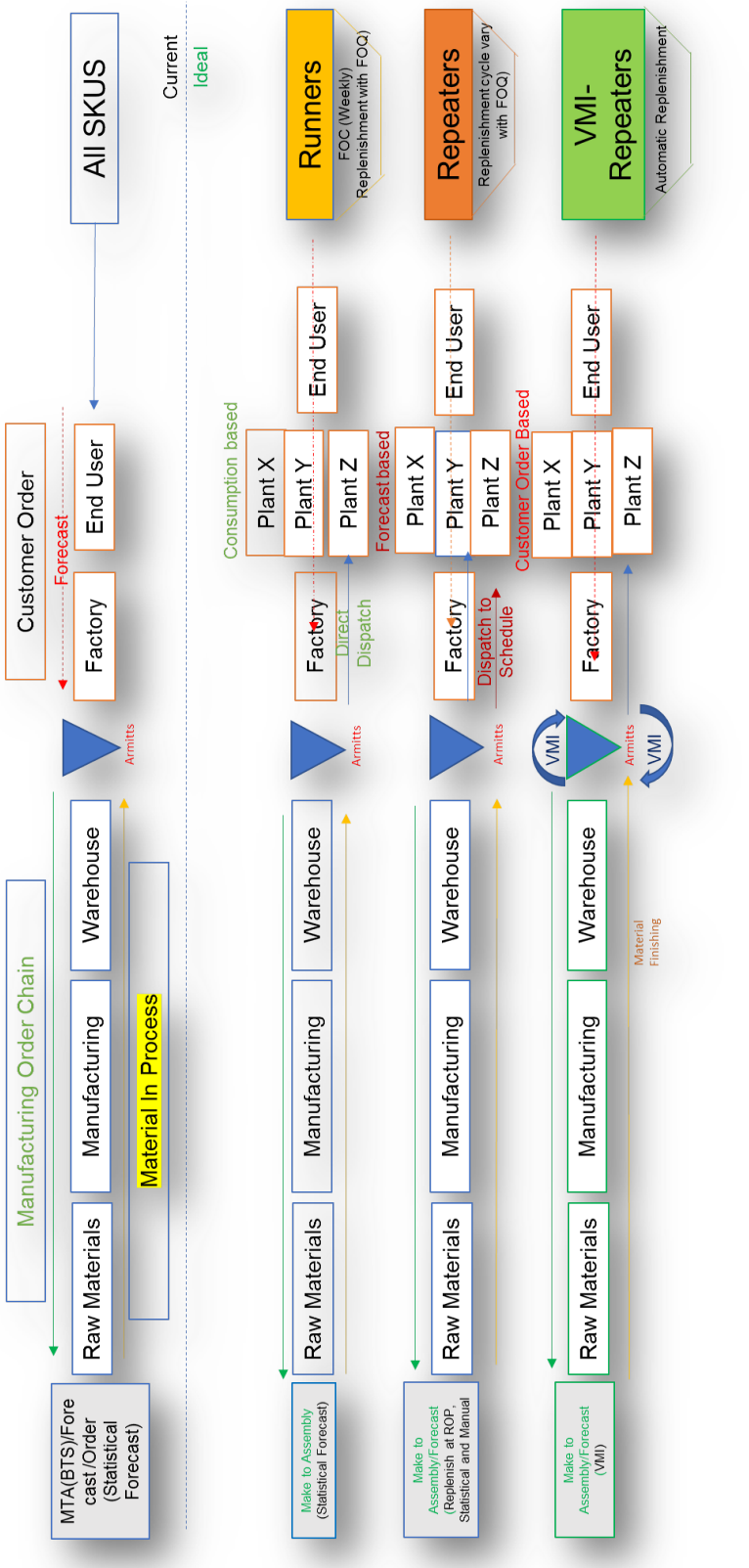

Figure 58: Updated Innovation Framework (Model 1)

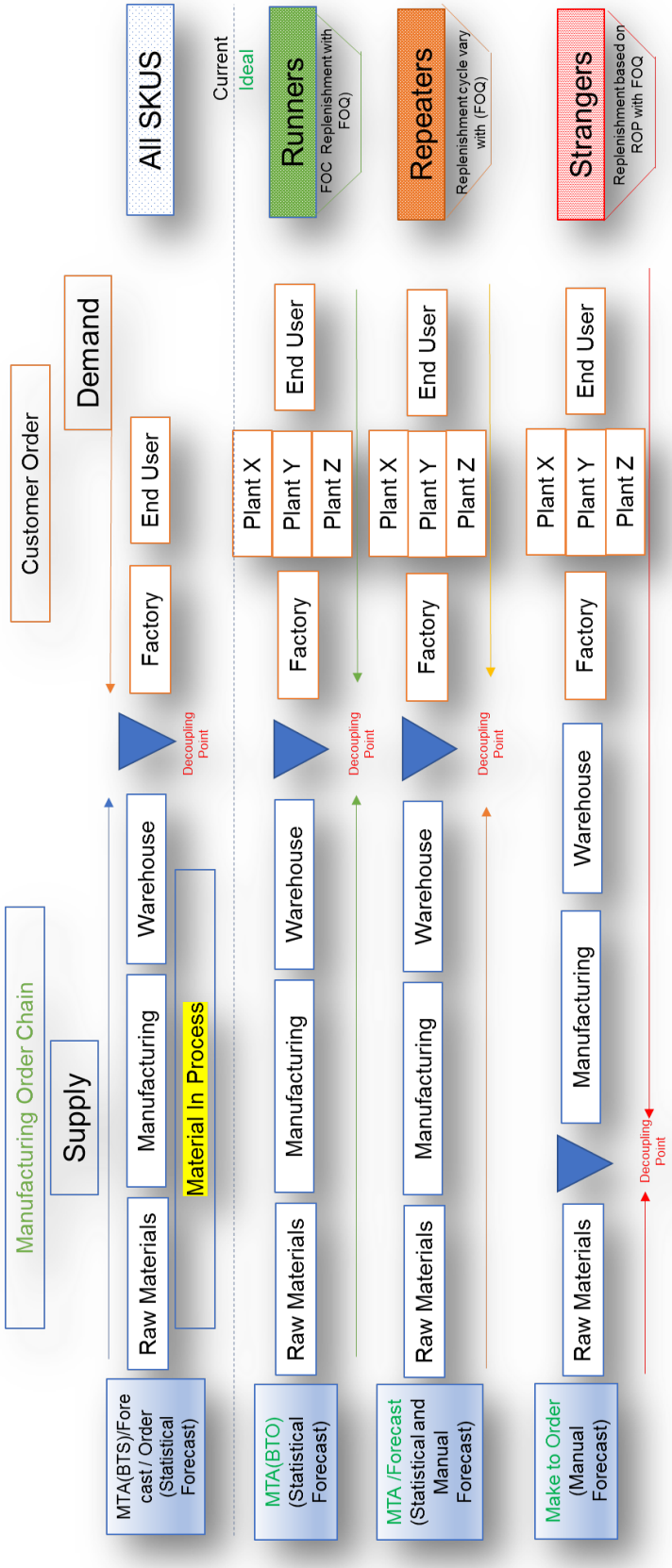

Figure 59: Updated Innovation Framework (Model 2)

5.1.2.5 Recommendations based on Segmentation Analysis

Based on the results of the data analysis and the literature review conducted during this research, some general recommendations are made for TATA Steel and JLR in different categories as listed in Table 25.

Table 25: General Recommendations based on Segmentation

Category	Current State	Recommendations (Model 1)	Recommendations (Model 2)
Forecasting Methods	Previous Years Historical, JLR Purchasing forecast based on Car sales,	Statistical and Manual Forecasting, VMI Replenishment	Statistical and Manual Forecasting
Inventory	Wednesfield, Armitts, The Tent, Halewood (Local Inventory)	Armitts (Central) for Runners, Repeaters and VMI-Repeaters	Armitts for Runners and Repeaters and no holding of stocks for Strangers
Manufacturing Strategy	MTA, MTO	MTA, MTF	MTA, MTF and MTO
Segmentation	ABC	ABC+RRS	ABC+RRS
Demand Planning	Local (Upstream)	Integrated End-End Planning	Integrated End-End Planning

The forecasting methods referring to previous year's demand data is replaced with a combination of statistical and manual forecasting based on the demand predictability of the segmented SKUs. The segmentation principles can be implemented at the manufacturing strategy level as well as the inventory management policy level. For the three manufacturing strategies (MTA, MTF and MTO) a "LEAN-AGILE" SC is recommended as the upstream supply is forecast driven while the downstream is demand driven. In the current scenario, despite the majority of inventory being held at Armitts, there are several other holding points across the value-chain irrespective of the demand profiles. The researcher advocates for a central holding inventory at Armitts with stock profiles for runners, repeaters and VMI-repeaters SKU, reducing the risk of fast-moving stocks hold at different inventory holding points. The tailored recommendations for each segment with respect to the characteristics of inventory, forecasting and planning are listed in the section.

5.1.2.5.1 Tailored Recommendations for Runner SKUs

As illustrated in Figure 60, the entire runner SKUs are set to be assigned with the MTA strategy. As 32% of volume and values is associated with this segment, the SKUs are of high strategic importance for the companies. Under the proposed integrated planning system, the downstream demand and planning data is considered in planning and the FG's are pulled in like a VMI at Armitts and enables the inventory to fulfil automatically based on the accurate consumption data in the entire value-chain. Based on the analysis, a weekly call-off for replenishment is performed based on the monthly requirement, benefitting in lead time reduction and less cost tied up in inventory. For TATA Steel, it gives an assured commitment of order that facilitates enhanced production capacity. The entire process can be based on statistical orders as no human intervention is required to confirm the high flowing orders. The orders are rarely scheduled, and the production lot size is equal to the shipping quantities. There are no shortages or missing shipments for these SKUs and the FG inventory is always in hand with TATA Steel.

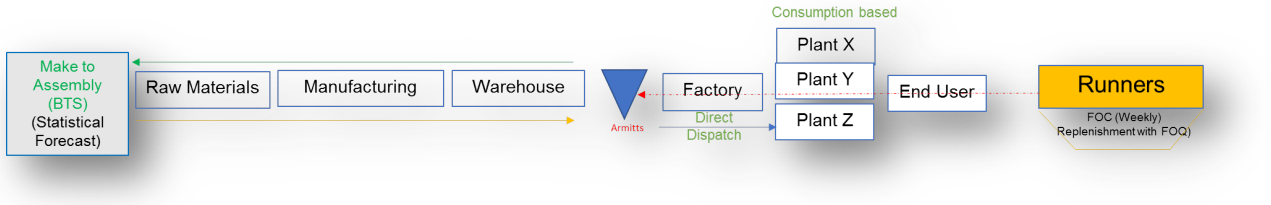

Figure 60: Tailored Strategy for Runners

5.1.2.5.2 Tailored Recommendations for Repeater SKUs

The demand for SKUs is predictable but less frequent than the runners. The replenishment is performed periodically. However, it is essential in this case to setting a fixed re-order point value and replenishment will be based on this ROP. It is important to have a combination of statistical and manual verification to confirm some orders. There are monthly reviews set for this segment and during the review the replenishment quantity and current stocks levels need to be addressed. The recommendation for this type of SKUs is shown in Figure 61.

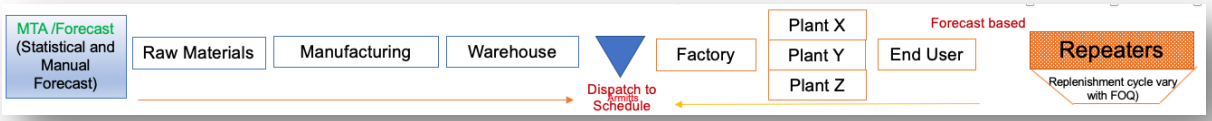

Figure 61: Tailored Recommendations on Repeaters

5.1.2.5.3 Tailored Recommendations for VMI-Repeaters SKUs

The SKUs falling in this segment as shown in Figure 62 contribute to a small proportion of low-volume repeaters with a strategy that can be based either on a VMI or an annual replenishment. The advantages for such a model are that TATA Steel can have a measured approach in their supplies which JLR can always pull in stocks from Armitts. The products can be de-listed easily in this category and the main objective here is to either increase the volume or entirely removing them from the product portfolio.

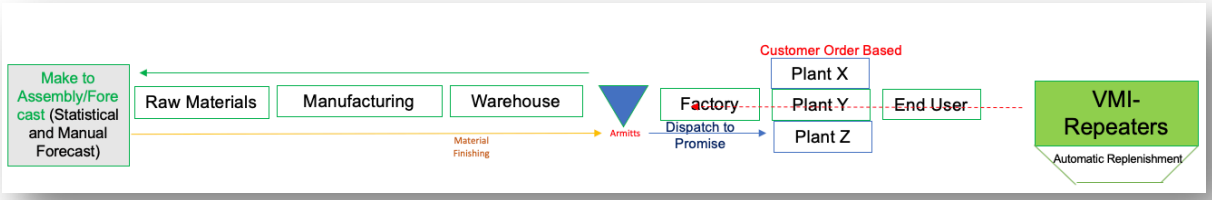

Figure 62: Tailored Recommendations on VMI-Repeaters

5.1.2.5.4 Tailored Recommendations for Stranger SKUs

The stocks falling in this segment as shown in Figure 63 contribute are identical like the VMI-Repeaters except that firm orders come with definite lead-times which allows TATA steel to deliver on promise without holding any stocks at Armitts. There is no review process required as this is dealt with form orders from JLR.

Figure 63: Tailored Recommendations for Stranger SKUS

5.1.2.6 Inventory Modelling

Based on the segmentation practices recommended in this research, an inventory model, depicting the business benefits of this research is presented in this section with two innovation models based on the section 5.1.2.5. Due to the data availability constraints, the modelled data is based only on the 31 SKUs that are limited to the in-direct supply. However, in the future work the entire demand data can be used to evaluate the benefits for the total supply of SKU. Currently, the batching rules that are set in SAP require more than half a coil in terms of weight, to trigger replenishment. In addition to an absence of a set time fence with in JLR or TATA Steel causes any demand coming in to the system with an automatic replenishment order. The inventory buffers are in place with respect to the "ToC" with no buffers set for any variability in demand and orders are replenished manually. Currently the SKUs are not differentiated, and orders are placed on all occasions of review based on the "ToC" and the plan aims to be in the 'Top of Amber' (less than 5 weeks of stock). In addition, the safety stock procedures are in place for all the SKUs, including the strangers. In addition, TATA Steel uses their safety time by increasing the lead time. The replenishment orders are planning manually by a review process of projected future inventory based on historical data and for all SKUs. As there are no set fixed order quantities or time fence set by the CMMS system in JLR, any short changes in quantity, prompts an immediate supply requirement to TATA Steel. The proposed model is based on an integrated FOC/FOQ inventory system, in which the order review is based on inventory positions at a particular fixed time and quantity. If the levels are found to be above the pre-set reorder point, no actions are taken. However, for runners or repeater segments, the inventory level is set to a variable quantity that is equal to the maximum stock level minus the current quantity held, or that is actually consumed or forecasted. This proposed model differentiates the SKUs in the first place by runners, repeaters and VMI-repeaters and then captures the forecasted demand for that particular SKU. For the runner segments, the order process is based on actual consumption or forecasted demand. In the next section 5.1.2.6.1 the analytical approach of the inventory modelling is explained.

5.1.2.6.1 Analytical approach for Inventory Modelling

In order to calculate the reorder point, it is essential to retrieve the demand rate and the lead time. The calculation is based on 1/2/4/8-week lead time window with average demand calculated based on the data provided. The basic formula to identify is shown in Equation 1. The DDLT represents to the forecast demand during the lead-time and the SS denotes to safety stock

$$\mathbf{ROP = DDLT + SS}$$

Equation 1: Re-Order Point (Source: Du)

However, Equation 1 can be used only if the demand is constant, in order to consider the variations in demand, the ROP is calculated using the Equation 2.

$$R = \bar{d}L + Z\sqrt{\sigma_d^2 \bar{L} + \sigma_L^2 \bar{d}^2}$$

Equation 2: ROP based on Variable demand (Source: Du)

Where $\bar{d}$ the average daily demand is with L denoting the lead-time, σ_d is the standard deviation, Z being the number of deviations with respect to the service levels and $Z\sigma_d\sqrt{L}$ being the safety stock. Lead-time demand is normally distributed with mean *μ* and standard deviation *s*.

$$R = \bar{d}\bar{L} + Z\sqrt{(\sigma_d)^2 \bar{L} + (\sigma_L)^2 \bar{d}^2}$$

where:

$\bar{d}$ = average daily demand
$\bar{L}$ = average lead time

$\sqrt{(\sigma_d)^2 \bar{L} + (\sigma_L)^2 \bar{d}^2}$ = standard deviation of demand during lead time

$Z\sqrt{(\sigma_d)^2 \bar{L} + (\sigma_L)^2 \bar{d}^2}$ = safety stock

The assumptions made is that the lead time is based on weeks and Z is the service value where Z = NORMSINV (Service level), for example Z=2.32 for a 99% service level. The next step is to determine the maximum and minimum stock level. The Equation 3 is used to calculate this value based on the minimum is calculated using the standard ROP equation and the maximum quantity is the function of the average demand, the lead time and the standard deviation.

(Demand x lead time) + (customer service level x standard deviation x square root of the lead time)

Equation 3: Minimum-Maximum Order Quantity (Source: Du)

5.1.2.6.2 Inventory Modelling Results

As illustrated in the Table 27, the modelling results validate around 24.45% inventory reductions in comparison to the current practices. The researcher is suggesting a fixed order replenishment cycle on a weekly basis for the Runner SKUs with two kinds of inventory: operating and safety stock. The calculation for required operating stock uses 24 weeks moving average and safety stock (shown in equation 4) which is calculated based on the, where safety factor is the probability of meeting the proposed service level based on probability density function.

$$Safety\ Stock = Safety\ Factor * Standard\ Deviation\ Demand * \sqrt{Lead\ Time}$$

Equation 4: Safety Stocks (Source adapted from Sun 2015)

90% of service levels indicate to a safety factor of 1.28, while 99% of service level has a safety factor of 2.33. The service level is directly proportional to the service factor (Sun 2015). Consequently, the safety stock increases as the service level increases. According to the segmentation results, no inventory is recommended for the stranger segments as this reduces a significant % of costs. The assumptions of the model are based on the moving average of demand (MA) for the 24 weeks of stock and with a service level (Z) of 99.9% for runners, 99% for repeaters, 98% for VMI-

repeaters and 905 for strangers. The researcher believes that due to limitation is data, only a sample of the benefits can be presented. In future research, it is advisable to consider the entire direct and in-direct supply for achieving more benefits. The optimal quantity for supply or the Economic Order Quantity was based on the average weekly demand volume but without the holding costs due to lack of data on the holding costs. The MOQ in combination volume throughput and the actual deliveries were taken in account to categorise the segments with runners typically having a lower MOQ than its actual monthly throughput with the consistent number of deliveries.

Table 26: Inventory Modelling Results (Model 1)

Current Practice			Inventory Modelling Results (Model 1)				Business Benefits	
LT (Weeks)	***Reorder Policy***	***Value***	***Segment***	***LT(Weeks)***	***ROP***	***Value (kg)***	***Value***	***%***
4	CMMS	147577	Runner	4	Monthly	61051	**36086**	**24.45**
			Repeater	4	SS+ LT*MA	40950		
			VMI-Repeaters	4	SS+ LT*MA	9490		
					Total	**111491**		

Table 27: Inventory Modelling Results (Model 2)

Current Practice			Inventory Modelling Results (Model 2)				Business Benefits	
LT (Weeks)	***Reorder Policy***	***Value***	***Segment***	***LT(Weeks)***	***ROP***	***Value (kg)***	***Value***	***%***
4	CMMS	147577	Runner	4	Monthly	61051	**45576**	**30.88**
			Repeater	4	SS+ LT*MA	40950		
			Strangers	4	-	-		
					Total	**102001**		

The business benefits as shown in Table 26 and 27 achieved shows substantial reductions of inventory in terms of costs due to the segmentation results. In the model 1, despite the reductions are bit lower, the customer service level is higher as JLR can pull stocks anytime from Armitts with stocks available at all time. The stocks holding costs are not calculated in this model due to non-availability of data and this must be

considered for any future work. A detailed list of business benefits will be explained in chapter 6.2. Summarising this entire chapter, the field visits to the companies provided a fundamental basis to understand and study the entire S&OP planning of the respective companies. A maturity assessment exercise was conducted to evaluate the overall performance of the companies based on the planning parameters identified during the filed visits. A big picture map with all key material and information flow parameters with handoff sequences was identified to evaluate if performance related barriers exist within the value chain. A future state big picture map is presented in chapter 6.3.2 to highlight better collaboration methods and minimise process duplications. Consequently, an enabler and inhibitor analysis were conducted to study the process and structures within and between the two companies and business implications were identified. The actions to turn the identified inhibitors to enablers are listed in chapter 6.2.3. The quantitative results were based on the segmentation analysis conducted during the course of the study. The analysis was conducted using a combination of demand profiling, ABC analysis and a volume throughput analysis that facilities to segment SKUs based on the demand profiles and classify as runners, repeaters and strangers. The results enabled to validate the Innovation Framework created during the literature review. To quantify the result of the analysis, an inventory model was created based on FOC/FOQ inventory methods that demonstrate significant costs reductions on using such a model.

Safety stock determines the chance of a stockout during lead time

- The complement of this chance is called the service level
- Service level is defined as the probability of not incurring a stockout during any one lead time
- The higher the probability inventory will be on hand; the more likely customer demand will be met.

5.2 Summary of the Chapter

In summarising this chapter, some preliminary findings on the key parameters of supply and demand based on the maturity assessment tool was highlighted based on the case studies performed at the two companies. However, it was still essential to

further study the demand process within JLR to understand the Bill of Material (BoM) relationship from the vehicle to slab grid point, as it was not evident if the demand signals are filtered from the car assembly line, synchronising the whole supply chain. In order to solve that challenge, a big picture map was drawn depicting the S&OP process and the entire information and material flow. The key planning issues are discussed in chapter 5.1.1.4 where the big picture map is presented in detail. In chapter 5.1.3.3 a future state collaboration was recommended for each of these above-mentioned profiles with improvement opportunities in terms of simplification of technology, communication and hand-offs, in addition to stabilisation of demand management. In the E&I analysis, some key structural aspects and the level of collaboration at process level were identified within and between the two companies. The initial indicators that implicate the overall performance of the business are identified in the form of inhibitors. The actions to turn the inhibitors to enablers will be explained in the chapter 6.3.3. The results of the segmentation analysis paved way to two different models and suitable recommendations were made in the chapter for the companies to model them in their respective inventory strategies.

6 Recommendations, lessons learned and future work

"You can't go back and change the beginning, but you can start where you are and change the ending"

Clive Staples Lewis (1898 -1963)

This chapter as outlined in Figure 64 presents the main innovation resulted from this Eng-D project and how the key solutions can minimise costs and enhance performance to TATA Steel and JLR. The chapter concludes with the key recommendations suggested to the companies based on the results of this research project.

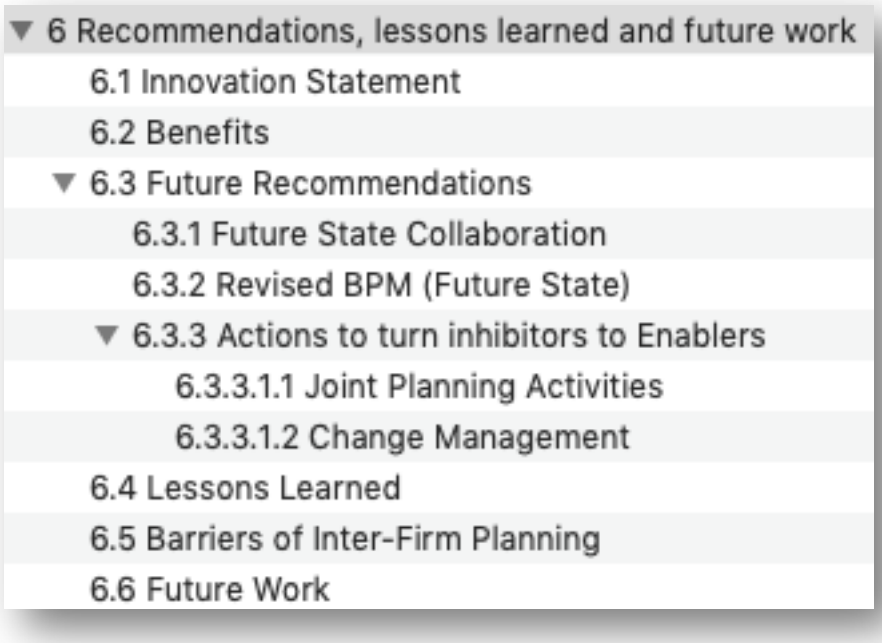

Figure 64: Outline of the Recommendation Chapter

6.1 Innovation Statement

The main innovation claim for this Eng-D project is stated as:

"Segmentation Principles used in an end-end value chain improves significant performance of multi-firm planning operations, in an Automobile Manufacturing industrial context".

This claim is driven by the key innovations this research has provided to practice are listed below:

1) Implementation of demand segmentation principles in an end-end planning (multiple-firm) architecture was addressed by identifying the demand profiles of the FG that is delivered in to the customer's inventory.
2) Using segmentation principles, the accuracy of forecasting by the supplier was highlighted in relation to actual customer forecast.
3) A future state collaboration model was developed that facilitates a connected SC exhibiting lower demand amplification.
4) Identified the structure and processes within and between firms that implicates business performance.
5) An excel tool based on FOQ/FOC inventory methods that highlight the business benefits in terms of inventory cost reduction

The summary of key innovations this research has provided to theory are listed below:

1) Collaboration issues between several departments in different companies working for the same business context is been investigated in this research.
2) This research focusses unlike the FMCG, on traditional business sectors like manufacturing where segmentation principles are not used commonly.
3) The researcher is suggesting seven different qualitative and quantitative approaches to be conducted within two companies namely demand profiling, Volume-Throughput analysis, Pareto, Demand decomposition, E&I Analysis, Value Stream mapping and a Maturity assessment exercise for enhancing the entire performance in a value-chain context.

6.2 Benefits

A summary of key benefits for TATA Steel and JLR that results from the solution developed during this Eng-D is shown in Table 28.

Table 28: Summary of Benefits

Innovative Solutions	Key Benefits
Demand Segmentation Principles	• Innovation Framework based on SC Segmentation where four segments (Runner, Repeaters, VMI-Repeaters and Strangers) are suggested for inventory management. • Inventory reductions of up to 24 – 31% depending the model
Demand Planning	• An integrated demand planning with downstream activities providing higher SC visibility. • Improved delivery performance based on bespoke strategies for segmented SKUs. (Runners are dispatched directly, Repeaters are dispatched based on forecast and repeaters are dispatched based on orders) • Prioritizing the Runner and Repeater SKUs for better customer satisfaction. • No production stoppage due to enhanced demand planning and delivery capabilities.
Synchronized Value Chain	• Steel smelted to meet gross actual demand. • The WIP buffers are set by demand volume. • The operation strategy is set according to the build rate per vehicle. • Planning with one demand signal that inherits the downstream demand variability. • Statistical and Manual forecasting. • Fixed order quantity and Fixed order cycle requirements that facilitate supply planning. • One single inventory holding point instead of multiple
Internal Business Process	• Understanding the key enablers and inhibitors that the overall impact of business. • Thorough assessment of supply, demand and inventory parameters by a Maturity assessment tool. • Improvised review processes with more on planning rather than executive • No Standardized KPI's quality, delivery and innovation. • Joint planning exercises between companies. • Different weekly, monthly and quarterly review modalities that focus on planning.

6.3 Future Recommendations

6.3.1 Future State Collaboration

The objective of this research was to enable the companies towards a value-chain orientation that synchronises the entire planning between the two-firms. In order to shift the local planning procedure to a systematic joint-planning procedure, system optimisation techniques are recommended that can eventually minimise the inventory and lead-time. The main aspects to the considered for such a joint-optimisation technique between companies are listed below:

1) It is important to build an operation strategy that is built on the rate per vehicle with the bill of materials in correlation of the steel grade required in kilograms, especially for TATA steel products.
2) Then a summated gross demand by steel grade can be created which enables TATA steel to forecast the amount of steel require per vehicle rate.

Joint-planning exercises are a key performance measure towards achieving the goal of a highly productive SC. Despite there are daily, monthly and quarterly review meeting that take place with the customer support team of TATA Steel and JLR, there is a strong focus on execution of deliverables, rather than planning for the future. The KPI's are standardized across all the meetings for delivery, quality and for any innovation practices set for the future. The daily meetings focus on the supply stats and issues by part numbers, the monthly meetings focus on delivery and the quarterly meetings are for now focussed in strategic supply. The researcher recommends the weekly schedule review meeting that focuses on managing any exceptions of demand and supply that is beyond the defined parameters. The monthly demand review meetings are set for review of the TATA Steel and JLR with agreement of 12-24 months demand for input in to the TATA Steel's S&OP. The quarterly supply chain review is then focussing on the monthly review in addition to discussion about any new product and commercial agreements between the two companies. As shown in Figure 65, the key objectives of the weekly meeting are to conform the security of the supply for the next seven-day period and mutually agree for any counter measures to address

exceptions. The review presents a present plan for execution and compares with the planned production plan. It also identifies gaps and measure impact in customer service, additionally; it reviews the next week plan and confirms inventory buffers. As shown in Figure 66, the monthly review is focussed on evaluating the demand accuracy of the previous months and agrees on issues that causes deviations and if possible, identify the root causes and ensure counter-measures are taken to address them. There is also a review of the next 12-14 months of demand in this review. The demand data is then confirmed in-line with the planning parameters and any changes are made in order to adjust the demand. There is also a mutual agreement on a demand forecast for the coming cycles. The agenda is focused on the demand accuracy with gaps presented between the estimated and the confirmed demand. There is also a mutual action list to be agreed on the biggest forecast deviations found at SKU level. The next cycle of demand which is set for the next 12-14 month is reviewed on a monthly basis and any deviations from the previous months are discussed. In both the weekly and the monthly reviews, the planners of TATA Steel and JLR are present and all the required participants are required to provide inputs. The output of the meeting is sent as a protocol to the SC managers and the S&OP manager. There is an approval process between the managers that focusses on demand forecast for the next period, any potential risks and mitigation actions. The quarterly review as shown in Figure 67 concentrates on issues that are in the monthly reviews in addition to the review of any new products in the next 12-24-month period. The meeting agenda is set to review the forecast accuracy, OTIF delivery and the quality issues held for the previous quarter. Demand forecasts for the next quarter and identified ricks and potential mitigation actions are approved during this review.

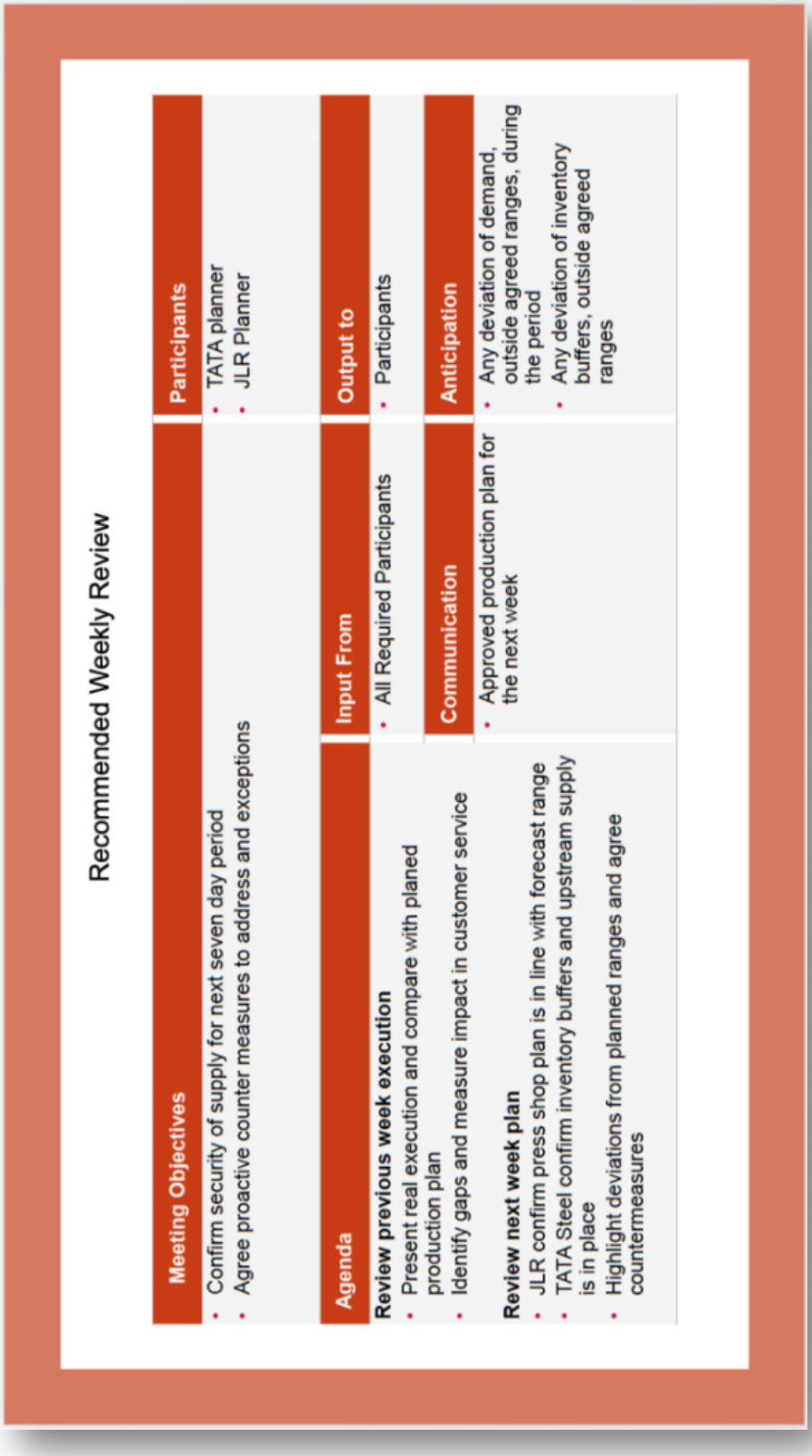

Figure 65: Recommended Weekly Review based on (Crimson 2017)

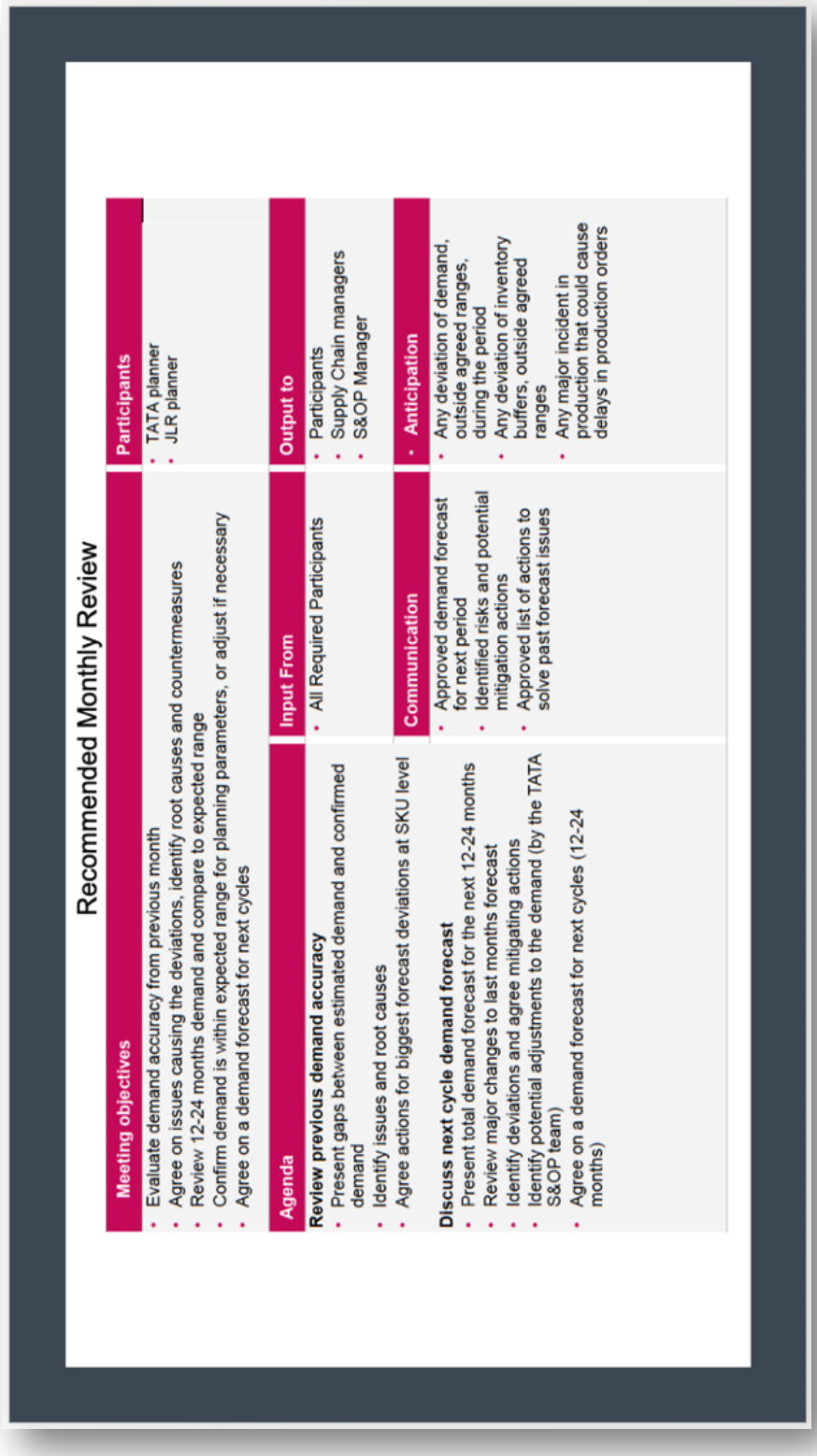

Figure 66: Recommended Monthly Review Based on (Crimson 2017)

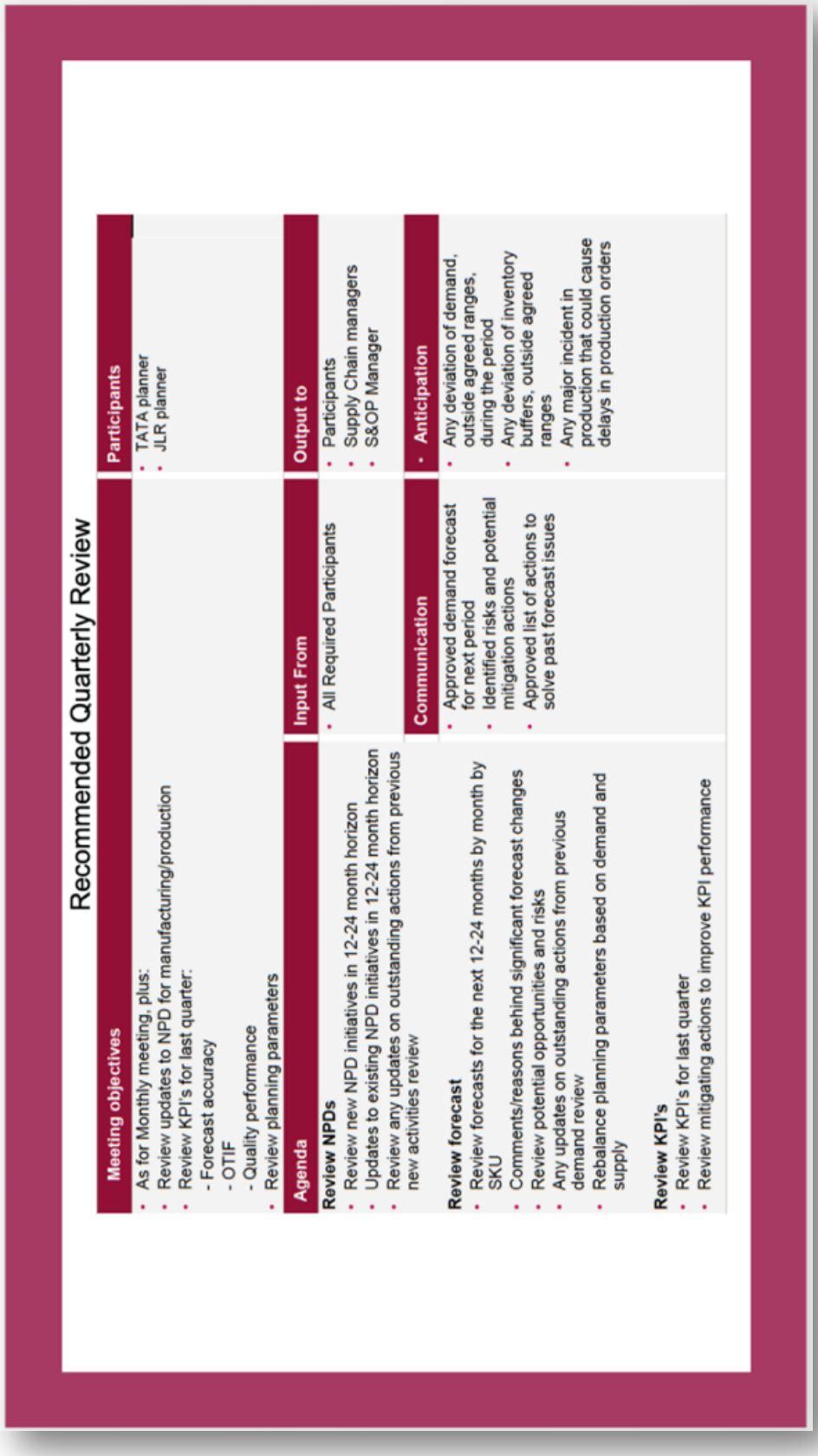

Figure 67: Recommended Quarterly Review based on (Crimson 2017)

6.3.2 Revised BPM (Future State)

A revised "Big Picture Map" as shown is Figure 68, recommends the warehouse facility at Armitts to have Inventory rules set by segmentation principles with MOQ's set from Zodiac. The inventories at Llanwern and Wednesfield are set only for staging purposes and not meant to hold any significant inventory. There are product wheels in place to simplify the changeovers. By setting a fixed production plan schedule to seven days a build plan is established for a 5-week horizon. The demand signals are then conditioned in CMMS, which is then received by the joint-demand planning team (Integrated Demand Planning) which performs weekly, monthly and quarterly meetings as described in chapter 6.3.3.1 and any variations in demand are identified with adequate policies set for escalations according the safety stock levels. There is a continuous revisiting of buffer quantities with the joint-planning team and manual orders are placed with set production plan for a 5-week window. By determining the optimal run sequence of the process to be a 5-week window, the inventory buffers are set and managed to fluctuate with acceptable ranges to absorb the demand variability. The result of such an integrated planning system is a SC which is connected between the vehicle build and steel supply.

6.3.3 Actions to turn inhibitors to Enablers

The key inhibitors found during the course of the study were:

1) Joint Planning Activities
2) Sharing demand information
3) Provision of resources
4) Change Management

As the 3rd inhibitor is beyond the scope of the research, the research will focus on the 1st, 2nd and the 4th Inhibitor.

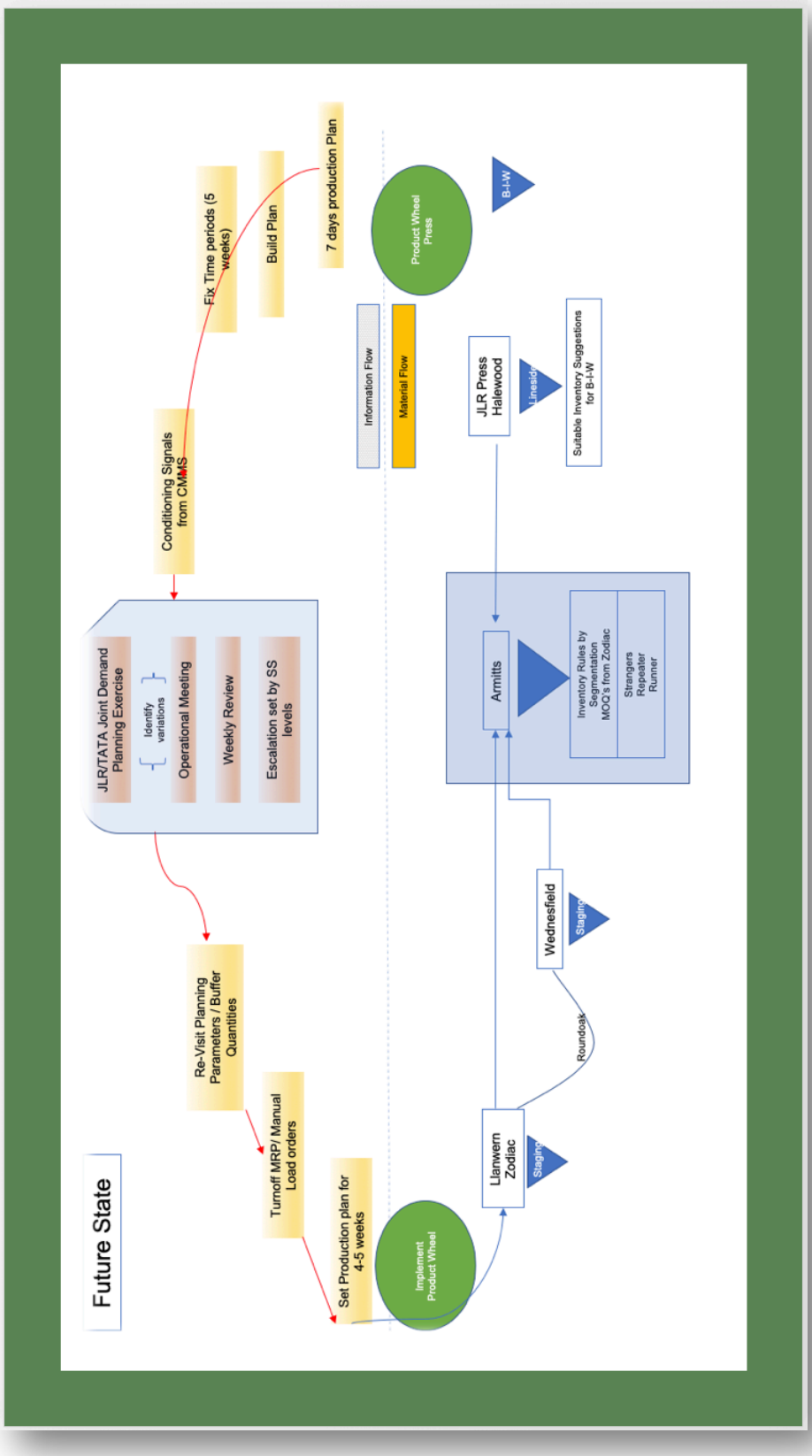

Figure 68: Future State Big Picture Map

6.3.3.1.1 Joint Planning Activities

As it was evident from the E&I analysis highlighted in 5.1.1.6, there is a definite need for joint planning and problem solving between the two companies, a road map as illustrated in Figure 69 is required to turn this inhibitor to an enabler.

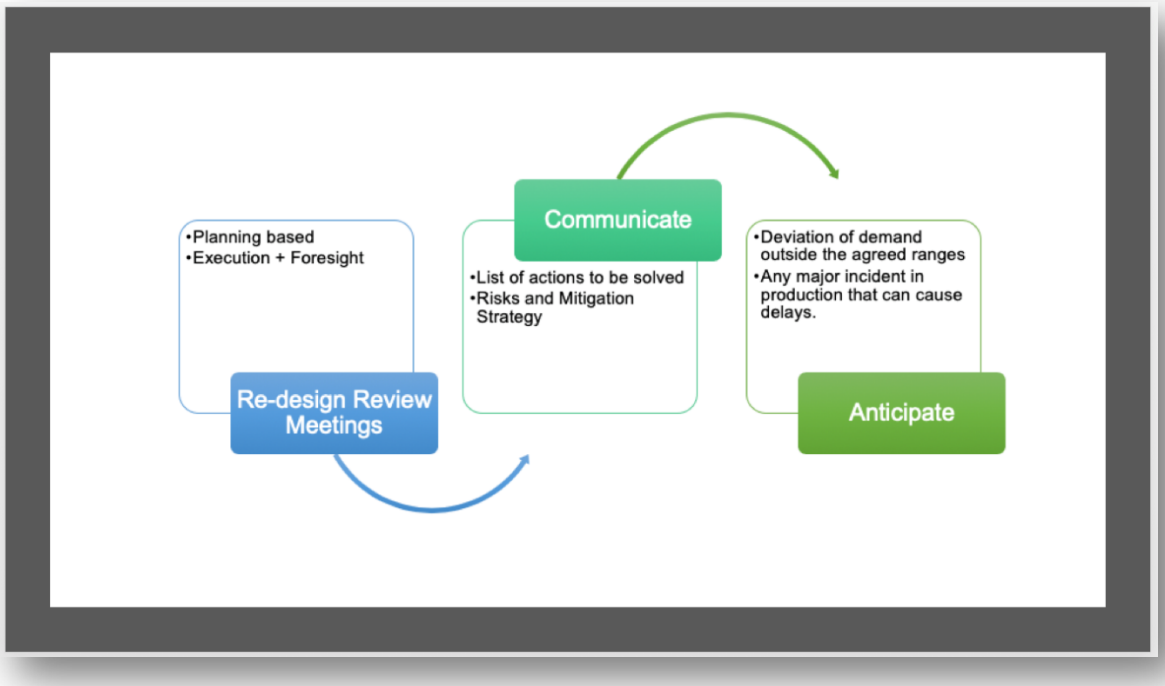

Figure 69: Actions for Joint Planning Activities

In this road map, the initial steps are taken to redesign the current meeting setup of execution to planning. The next phase is to establish communication channel that transmits the list of actions to be solved based on priority. The risks and mitigation strategy along with the resource requirements is communicated to the top management. The next phase being the anticipation phase where there are measures based on anticipation of deviation of demand or any major incidents that could disrupt the performance of the SC.

6.3.3.1.2 Managerial Implications

On analysing the key IT interfaces, a range of different ERP/MRP systems are used that are addressed in 5.1.1.1 similar to CMMS used by JLR that creates a clear disconnect between the planned demand signal and the execution call-in. The researcher recommends an integrated planning system which is run by a single

interface of SAP and not singular applications run by individual teams. The aim of the change management process is to maximise efficiency while not disrupting the process (Lloyd-Walker & Walker 2011). However, disruptions cannot be avoided in the process of innovation (Bower & Christensen 1996). The researcher advocates a change management model based on Lewin (1947). The process is illustrated in Figure 70. The three-phase model can be used by TATA Steel and JLR where a non-disruptive, non-priority-based process is identified and at the first step, unfreeze the process and then implement a new process, before refreezing the process. The results can be then piloted based on satisfactory results. Once the pilot is successful, a similar change process can be targeted on other processes. The advantages of such a change management system are that change much not be made on a larger scale and at once.

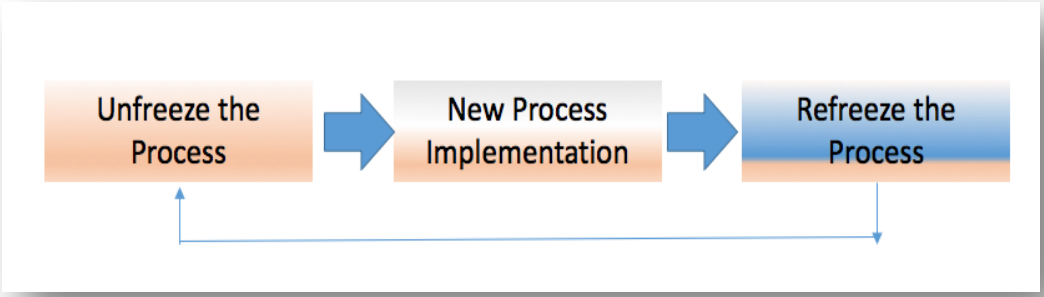

Figure 70: Kurt Lewin's Change Process: Source adapted from Lewin 1947

In addition, the rationale of why industries should consider supply chain segmentation is listed below:

- **Minimizing configuration complexities:** An extensive customer analysis is required to initially segment the SC (Wong et al. 2012). This requires understanding of how customers behavioural pattern imply when purchase and servicing is performed, and what combinations are profitable (Gattorna, J.L., Chorn, N.H. and Day 1991). When customer purchasing pattern is identified, segmentation based on needs of customers can be identified and segmented. "Dell, as described in (Simchi-levi et al. 2013), identified a reduction of 99% in the number of configurations offered when identified the behavioural pattern of customer". Similarly, delivery methods and specific

product design for a specific market can also reduce complexity by segmentation (Disney & Towill 2003)

- **Identification of synergies:** Different products offer different value propositions to different market segments and firms can leverage with synergies derived from understanding the economies of scale to reduce costs.(Bowersox, Donald J., David J. Closs 2000) For example, as a result of standardizing component manufacturing and placing a similar procurement policy across segments, the manufacturing department can usually be used by all supply chains minimizing a dedicated production facility to serve a specific customer segment. By this platform of synergy sharing, the primary focus can be platform or model based, allowing firms to propel economies of scale.
- **Emphasis on standardization:** Using standardized components in various segments in product design can optimize the level of configurability and provides an open case to leverage volume across segments.(Ernst & Kamrad 2000) For example with each customer having its own configuration but with large batch sizes and many common standard components can be segmented in the corporate department, in correspondence to the online segment where customers can configure their own solution, based on standard components. While the corporate business might be best served by a Configure-to-Order strategy and the online segment by a Build-to-Order strategy, both can be based on a product design in large with common parts.(Alexander Bender 2013)
- **Designing the SC:** By creating a strategy to evaluate the impact of design and development decisions on the portfolio, accepting what the product team creates can be negated. This facilitates the product managers to create efficient designs on new products for new markets impacting the costs and other SC ramifications(Shrivastava 1985).
- **increase Integration:** In order to efficiently manage and coordinate manufacturing capacity for the different supply chains, firms need a stable but single process. This is vital parameter for efficiency to drive economies of scale in a shared manufacturing.(van der Vaart & van Donk 2008) A stable but single S&O process across all supply chain segments will integrate demand, supply and

inventory, and ably accommodate production capacity to the various supply chains based on real and forecasted demand.

- **Align and Apply Customer Value:** The customer value and needs is the key success parameter for driving the optimal operational strategy in aligning with the customer needs and to understand the need of an efficient process. Any disconnected strategy without the needs of the customer causes decline in customer service level and increases inefficiencies. The recognition of different needs from the customer drives the SC segmentation responsive strategy in fulfilling the order, streamlining the customer service levels, lowering the inventory costs with increased responsiveness. (Flint et al. 2008).

6.3.3.1.3 Optimal Inventory Mix

In this research, a 24.45 % of inventory reduction was achieved by using a Fixed-Order-Replenishment cycle. However, in future work, an optimal mathematical modelling is suggested that incorporates two different inventories. This will enable cost reductions and optimisation of inventory policy based on a mix-inventory model rather than independent calculations.

6.4 Lessons Learned

There is a philosophical aspect in summarizing the lessons learned in any particular project. The experience gained during the course made the researcher more patient and tolerant for dealing challenges in all aspect of life beyond the scope of the research project. This project was challenging in different aspects namely: managerial, technical and organisational. As there were multiple stake holders involved in the project at different locations across the country, managing the project was always going to be a challenge. As the organisations involved are working in a dynamic environment and in turnover shifts with minimal factory closure, their operations are much more challenging that other industries. Due to the uncertainty in the production lines and due to unexpected stoppages of production line or critical supply chain issues, the managers involved in the project often had to re-schedule or cancel the entire meetings within short notice. The re-scheduled meetings had its own shares of issues to be scheduled again with the correct agenda and with the same set of

stakeholders. The researcher was fortunate that the department set additional resources in the form of a project manager who coordinated most of the managerial aspects in the last 6 months of the project. As this project was designed for engineering doctorates, which have pervious management background before starting this study, however the researcher anticipated such incidents and made a project management plan based on previous experience. On the technical aspect, there were different set of data sets from various sources across the value chain. However, the scope of the data was limited. The data sets were sent in a PDF format which took many weeks to convert them in to a workable format in Excel. However, the critical constraint was analysis of the demand data which required access to the entire demand data from all the plants of JLR. The data was restricted only to the collection receipts at Armitts and an assumption based on the big picture map was tailored on formulating the entire demand pattern. In future work, it is essential to have access to the entire demand data from all the plants. On the supplier side, despite the inventory analysis was performed based on the Finished Goods, it would be essential to have access to the raw materials and the work in progress portfolio. Although, this concept displays numerous benefits for the planning departments at the respective companies and efforts to use this framework in a bigger scale of economy is already planned with TATA steel and with JLR, the researcher still believes that the collaboration framework needs high level involvement and support from top managements of both companies. There is a general reluctance in using new systems as the fear of disruptions often lead to working in a safer environment that might be unproductive but reliable. The companies involved use IT interfaces which are tested but not adaptable to any changes. There is also a wider consensus on system change and TATA steel has invested in a highly functional and modern SAP system. However, on detailed study performed during the individual field trips to the company, not many groups rely on the SAP systems. They have developed an individual, standalone application which is driven due to the constraints of the SAP platform. An open platform to communicate these critical issues to the central business analyst team at SAP is vital for the team and at the current state there are no measures in place. The researcher also identified that there is an over dependency of some critical team members who are involved in planning and operations. If one of the team members leaves to another organisation

or fall sick, the entire sales and planning team will be in a crisis-mode. A risk-mitigation strategy is required for a company of this scale and for any future work; the teams must not be over dependent on key personnel and have a central point of contact for all data requirements. The results of the study to a great extent highlight the current practices across the value chain but in perspective of the future, there was minimal strategic information available from both the companies in the areas of project management, demand planning and forecasting methods. There are several coordination personnel to deal with individual requests queries, solve problems and deliver reports for the current business transactions. The companies offer professional development training to their employees and sincere efforts can be made to offer a joint training for all the key members of staff involved in this business transaction. As the researcher strongly believes that personal relationships build over the tool's IT tools, can ease and strengthen any relationship

6.5 Barriers of Inter-Firm Planning

To construct Integrated Inter-Firm planning process architecture, two potential barriers were identified during the study:

1) **IT / ERP system Integration**
2) **Differentiation of Demand**

IT / ERP System Integration]

Both the companies have different internal processes that work in eliminating inventory buffers within several internal business units. A lot of real-time information is shared with in these units and a majority of the companies use ERP systems (Christopher & Holweg 2011) However, on integrating with external platforms, there is a necessity to involve multiple-levels of safety measures in real-time and a consolidated system integration platform between two IT systems. In this research context, inter-firm planning is foreseen but the innovation model is based on data from independent ERP systems and after analysis, providing a demand segmentation approach within their processes in an overarching tool, which can be used by two companies, independently. However, for future research, it is necessary to identify the critical factors for successful cyber-physical interfacing between two companies based

on Industry 4.0 principles. According to (Khaparde 2012), critical factors for a successful implementation are:

1) Clear understanding of strategic goals
2) Identify multi-site issues
3) Commitment by top management.
4) Project Management

During the course this study with the involved companies, this was addressed in multiple sections of chapters in 5.0

Differentiation of Demand

The issue concerning overestimation of demand from typical sales functions occur very frequently in companies, ensuring stocks are available to fulfil orders (Cooper et al. 1997). In this current research scenario, joint planning using segmentation principles that consider not only by the upstream processes generated but also the customer's downstream processes with yields is relayed to the supplier. This challenge is addressed in the innovation framework chapter 3.0 and segmentation analysis chapter 5.0.

6.6 Limitations of Research

1) The order fulfilment methods as indicated in chapter 5.1.1.1 indicate two processes for Make to Assembly and Make to Forecast. In this particular study, the Theory of Constraints (ToC) was based on a given set of colour coding scheme provided by TATA Steel. However, the study did not show the proportion of inventory savings in relation to the ToC. In future work and with an extended scope for the project, if the ToC constraints are mapped with the actual inventory status based on the segmentation analysis performed during this research, the SKU's with demand profiles can be clearly identified in relation to the TOC.
2) In the E&I analysis, the objective was to study the processes within and between the companies. However, in future work, the author proposes to compare the differences across the two firms in order to minimise the self-

reporting biases that may occur by assessing the counter-parts of the opposite companies, as opposed to assessing only the individual enablers and barrier with in the companies.

3) The descriptions of the 31 SKU's analysed during the scope of the project is generic as the researcher had constraints in collecting the information about the SKU's. If the SKU description is provided in detail, it becomes easier for the future work to identify the criticality of SKU's in terms of engineering descriptions and part movement across the end-end value chain. In addition, if the parts are described in detail, the bill of materials can be tracked in accordance to the quantity of steel provided by one single supplier. In the perspective of visibility within this research, only part numbers are coded in the segmentation analysis and the interpretation of the final analysis can be a challenge for readers with no information in correlation to the part numbers and the actual parts used at the final production facility.
4) In the final segmentation analysis, the closeness between some of the SKU's in terms of lumpy and erratic demand profiles, can cause managerial implication. There are better approaches like filtering the high-volume SKU's and focussing on the SKU's which are deemed to be runners and repeaters can minimise differentiation errors when handing closer demand profiles.

6.7 Future Work

The scope of this integrated planning project based on the segmentation principles in an end-end value chain still strongly depend on human creativity, problem solving competence, mutual sharing of goals, information and data, which is backed by strong MRP and ERP systems. In the current scenario, real-time production planning and control does not exist, and the entire demand and supply operations is performed with static historical data in the upstream of the SC. Despite efforts taken during the research to consider downstream demand, the data sets were static, and the scheduling parameters are not flexible and any variability in demand is not automatically updated in real-time with manual intervention. In future work, a real-time planning system offers more flexibility by identification of demand variability and the

source within the entire value-chain is foreseen. A 'Cyber Physical Production System' based planning system is envisioned for future work. This future based system will be based on dynamic data set in a real-time environment that tracks not only the actual customer order but calculates the material availabilities and the current stock levels using segmentation principles, to calculate the optimal material availability platform along with optimal delivery platform for the materials to arrive in time, in full and at the right location. The management of both the companies were interested to develop a decision-making tool (a visual dashboard) in future work with WMG to facilitate decision making process which relies on several interfaces that are in different formats and with departmental contacts. The objective of such an integrated management framework is that the top managers of both the companies can monitor the entire value-chain in a one single visual format with live display of stock levels, demand transformation, production planning and delivery status. Currently, the system is based on manual interventions and physical meetings of staff that enables them to review the processes. This causes a miss link between the manufacturing strategy and the top management. The proposed future system which is connected with cyber-physical data architecture can integrate real-time production planning with the top-management's business strategy.

7 Conclusions

"In literature and in life we ultimately pursue, not conclusions, but beginnings"

Sam Tanenhaus

In this final chapter of the study, a review of the objectives will be conducted along with the concluding thoughts made by the researcher. The outline of the chapter is presented in Figure 71.

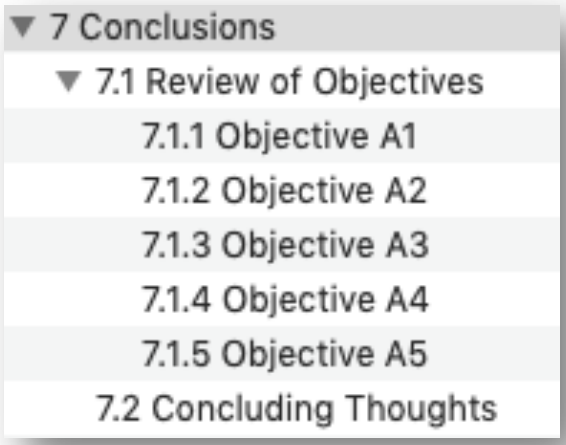

Figure 71: Outline of the Conclusion Chapter

7.1 Review of Objectives

This Eng-D Study's main objective was: "*To explore the opportunity to improve inter-firm productivity through the application of demand profiling"* in an end-end value-chain between TATA Steel and JLR. To achieve this, five research objectives were set in Chapter 1. In the upcoming sections, all the objectives will be individually reviewed.

7.1.1 Objective A1

'To examine the current stage of planning process, delivery strategies, performance levels and studying the demand, supply and inventory process'. (A1)

Prior to the start of this project, despite the collaboration that already existed between TATA steel - JLR and in addition to both companies originating from a single group of

companies, there was minimal visibility on the planning processes of the companies especially in S&OP processes. The analysis presented in 5.1.1.4.2 and 5.1.1.4.3 demonstrates in-depth understanding of the information gathered by the researcher to draw a big picture map that presents the entire planning processes and delivery mechanisms in both the companies. The analysis presents the current state of the information and material flow at both these companies and in-detail describes the entire flow from demand creation to FG creation. In addition, the order management and fulfilment methods of the receptive companies were identified with explanation on the 'ToC' that is used by TATA Steel for order management. The two different methods of supply are highlighted with the inventory holding points. This analysis was a key aspect of this research to identify the several enablers and inhibitors that is to be later discussed in the objective A3. During the feedback workshops, the big picture map was presented to both the companies, highlighting their flow process. Based on recommendations from the companies, a future state design is proposed (A5). The review procedures were analysed and new review models suitable for joint planning procedures are highlighted in section 6.3.1

7.1.2 Objective A2

'To developing inventory models that highlights potential business benefits for the companies involved based on demand profiling (A2)'

As the Eng-D project focusses on contribution to business innovations, a future state inventory model was designed using the FOQ-FOC inventory methods, highlighting around 36% of inventory reduction based on the Innovation framework and the data analysis conducted in 5.1.2.6. This quantitative exercise uses segmentation principles for this particular study. In chapter 2.3, a need of an integrated planning system based on the core principles of segmentation was discussed to conceptualize this Eng-D study. This is supported with explanation of the motive of demand profiling, listed in research literature that is submitted as 3rd Portfolio during the course of the study. A major part of this objective was achieved by using these segmentation principles as listed in 5.1.2. It is evident that by segmenting the SKUs based on Runners, Repeaters

and Strangers, new inventory policies can be set to minimise holdings on one front and on the other to manage demand variability with better forecasting techniques.

7.1.3 Objective A3

'Investigating the structure and processes within and between firms that affect the business performance by performing an Enabler and Inhibitor Analysis (A3)'

In order to evaluate the structure and processes of the companies, a qualitative assessment based on an online 'Qualtrics' based questionnaire was circulated to leading SC managers of the two companies. The results shown in 5.1.1.7 showcase the organisational structural behaviour, the business performance metrics and the joint information sharing practices within and between these companies. As the entire study advocates for an integrated planning platform, the results obtained during this phase of the study is instrumental in addressing future state collaboration as presented in 6.3.1. This future state collaboration model is based on the E&I analysis and the maturity assessment exercise explained in A4. A list of enablers and inhibitors is presented with further recommendations to turn the inhibitors to enablers highlighted in 6.3.3. The E&I analysis was presented to the companies during the workshop to the manager of the two companies and the validated the results and have shared internally to the concern teams.

7.1.4 Objective A4

'To assess the planning and collaboration issues through a maturity assessment tool (A4)'

Based on Crimson (2017), a maturity analysis exercise was conducted in TATA Steel and JLR to identify the current competency levels of the processes in the area of customer relationships, joint planning, demand management, replenishment and scheduling. The assessment was conducted during the field trips with all the critical team members involved in the above-mentioned areas. Several parameters relating to S&OP processes were accessed and ranked according to their profile levels namely: Competency, Proficient and Mastery. This exercise assessed the current state of maturity in these key processes as shown in section 5.1.1.2. The maturity

assessment results were communicated to the respective companies with recommendations of desired service level of the maturity the companies need to target to achieve improved productivity. The exercise in addition helped the companies to identify a specific roadmap as addressed in the revised BPM section 6.3.2 for achieving the maturity goals and identifying the value of such a service to the companies in enhancing productivity.

7.1.5 Objective A5

'To propose a pragmatic future state design in the form of a big picture map enabling the companies to exercise better planning procedures (A5)'

Integrated planning solutions was one of the core objectives and with a thorough qualitative and quantitative analysis conducted during the entire duration of the study, a future state big picture map was drawn showing a LEAN with minimal hand-off points and information accuracy. The BPM map is presented in 6.3.2. All the stakeholders of this research were involved in the final dissemination workshop where the future state model was presented.

7.2 Concluding Thoughts

This study is based on enhancing productivity in a UK manufacturing context, specifically set up in an automobile manufacturing context. Despite companies setting visions and targets for enhanced collaboration for mutual joint-planning, this research indicates that two major companies dealing with huge transactional volumes of steel have fundamental challenges, like a demand-supply mismatch that affects the entire productivity of the SC. Skinner (1964) already predicted such a missing link between manufacturing and business strategies in the late 60's and despite the current generation of companies using high-level analytics or project management tools, they are unable to solve the planning issues. This is due to lack of insights on the entire value-chain of the transaction. The researcher recognized that the vision statements of some groups within the companies were just based in execution of one or two tasks that were appropriate for that specific request and any inter departmental collaboration

was beyond their capacity or interest. The big-picture of connecting the entire value chain with meaningful understanding of processes is still novel for departments within companies. The departments are solving issues in a reactionary manner, "*fire-fighting*" with over dependence of key personnel. This research advocates for an integrated-joint-planning system that is not only based on execution but has attributes of actual consumption with consumption-based forecasting techniques designed for the companies. As customer is still the king in any business, the suppliers require a combination of enhanced management techniques and simple meeting agendas that cover the entire horizon of production planning to meet the demand of the customer. It is essential that the top-management involves in key strategic issues to SC and its effect in productivity. This research focuses on managing demand and designing strategies that can improve the overall performance of the value chain. However, without the companies orienting towards a value-chain perspective, the task of joint planning exercises is due to fail. The end-end planning is a critical aspect to improve the overall productivity and future research will pave way to cyber physical software architectures that connects the entire production planning in real-time but without segmentation of demand using the demand profiling principles, the process is still not efficient, as wrong goods will be hold at wrong places or the right goods will be not delivered on time at the right location.

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9 Appendix

9.1 Ethical approval for this study

PRIVATE
Mr Rajesh Shankar Priya
WMG
University of Warwick
Coventry
CV4 7AL

24 January 2018

Dear Mr Shankar Priya,

Study Title and BSREC Reference: *Enhancing UK Manufacturing by enabling a Value Chain Orientation* REGO-2017-2146

Thank you for submitting the revisions to the above-named study to the University of Warwick's Biomedical and Scientific Research Ethics Sub-Committee for approval.

I am pleased to confirm that approval is granted and that your study may commence.

In undertaking your study, you are required to comply with the University of Warwick's *Research Data Management Policy*, details of which may be found on the Research and Impact Services' webpages, under "Codes of Practice & Policies" » "Research Code of Practice" » "Data & Records" » "Research Data Management Policy", at:
http://www2.warwick.ac.uk/services/ris/research_integrity/code_of_practice_and_policies/research_code_of_practice/datacollection_retention/research_data_mgt_policy

You are also required to comply with the University of Warwick's *Information Classification and Handling Procedure*, details of which may be found on the University's Governance webpages, under "Governance" » "Information Security" » "Information Classification and Handling Procedure", at:
http://www2.warwick.ac.uk/services/gov/informationsecurity/handling.
Investigators should familiarise themselves with the classifications of information defined therein, and the requirements for the storage and transportation of information within the different classifications:

Information Classifications:
http://www2.warwick.ac.uk/services/gov/informationsecurity/handling/classifications
Handling Electronic Information:
http://www2.warwick.ac.uk/services/gov/informationsecurity/handling/electronic/
Handling Paper or other media
http://www2.warwick.ac.uk/services/gov/informationsecurity/handling/paper/.

Please also be aware that BSREC grants **ethical approval** for studies. **The seeking and obtaining of *all* other necessary approvals is the responsibility of the investigator.**

These other approvals may include, but are not limited to:

www.warwick.ac.uk

1. Any necessary agreements, approvals, or permissions required in order to comply with the University of Warwick's Financial Regulations and Procedures.
2. Any necessary approval or permission required in order to comply with the University of Warwick's Quality Management System and Standard Operating Procedures for the governance, acquisition, storage, use, and disposal of human samples for research.
3. All relevant University, Faculty, and Divisional/Departmental approvals, if an employee or student of the University of Warwick.
4. Approval from the applicant's academic supervisor and course/module leader (as appropriate), if a student of the University of Warwick.
5. NHS Trust R&D Management Approval, for research studies undertaken in NHS Trusts.
6. NHS Trust Clinical Audit Approval, for clinical audit studies undertaken in NHS Trusts.
7. Approval from Departmental or Divisional Heads, as required under local procedures, within Health and Social Care organisations hosting the study.
8. Local ethical approval for studies undertaken overseas, or in other HE institutions in the UK.
9. Approval from Heads (or delegates thereof) of UK Medical Schools, for studies involving medical students as participants.
10. Permission from Warwick Medical School to access medical students or medical student data for research or evaluation purposes.
11. NHS Trust Caldicott Guardian Approval, for studies where identifiable data is being transferred outside of the direct clinical care team. Individual NHS Trust procedures vary in their implementation of Caldicott guidance, and local guidance must be sought.
12. Any other approval required by the institution hosting the study, or by the applicant's employer.

There is no requirement to supply documentary evidence of any of the above to BSREC, but applicants should hold such evidence in their Study Master File for University of Warwick auditing and monitoring purposes. You may be required to supply evidence of any necessary approvals to other University functions, e.g. The Finance Office, Research & Impact Services (RIS), or your Department/School.

May I take this opportunity to wish you success with your study, and to remind you that any Substantial Amendments to your study require approval from BSREC before they may be implemented.

Yours sincerely

pp. E Digard

Dr David Ellard
Chair
Biomedical and Scientific
Research Ethics Sub-Committee

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9.2 Participant Information Sheet

PARTICIPANT INFORMATION SHEET
version 2, 09/01/18

Study Title:	Enhancing UK Manufacturing Productivity by enabling a Value Chain Orientation.
Investigator(s):	Rajesh Shankar Priya

Introduction

You are invited to take part in a research study. Before you decide, you need to understand why the research is being done and what it would involve for you. Please take the time to read the following information carefully. Talk to others about the study if you wish.

(Part 1 tells you the purpose of the study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study)

Please ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

PART 1
What is the study about?

The scope of the project is to explore the opportunity to improving the supply performance through the application of demand profiling. The ideal situation is to collaborate with suppliers delivering materials in a short time, adhering to the delivery dates, leading to highly efficient on-time delivery and satisfying fully the customer objectives. Solving this supply demand mismatch between the customer and the supplier significantly enhances the productivity of the company and guarantees higher customer satisfaction level, at a lower total cost to the entire supply chain. This research intends to develop an end to end segmented supply strategy for JLR and its steel supplier (Tata Steel), which will improve the productivity of both Tata Steel and JLR.

Do I have to take part?

It is entirely up to you to decide. We will describe the study and go through this information sheet, which we will give you to keep. If you choose to participate, we will ask you to sign a consent form to confirm that you have agreed to take part in the interview, you are giving your consent for the information that you have supplied to be used in this study. You will be free to withdraw at any time, without giving a reason and this will not affect you or your circumstances in any way.

What will happen to me if I take part?

If you agree to take part, you will be approached by the Investigator to take part in an interview, this will take 1.5 hrs of your time to discuss some of these underlying issues:

Enhancing the planning process of your business unit
Challenges and possible solutions for the business unit
A tool for demand profiling

In addition to the interview, history of sales/order data (for the past 36 months), Inventory Data (Present and historic) and forecast data for the previous and upcoming 12 months are required in an excel or similar format.

What are the possible disadvantages, side effects, risks, and/or discomforts of taking part in this study?

There are no foreseen disadvantages and risks.

What are the possible benefits of taking part in this study?

Research/academic perspective of the application used in industry
Future trends and innovation outlook
A tool for planning

Expenses and payments

No reimbursements

What will happen when the study ends?

The participants will be invited for the dissemination workshop and will be provided with the research results

Will my taking part be kept confidential?

Yes. We will follow strict ethical and legal practice and all information about you will be handled in confidence. Further details are included in Part 2.

What if there is a problem?

Any complaint about the way you have been dealt with during the study or any possible harm that you might suffer will be addressed. Detailed information is given in Part 2.

This concludes Part 1.
If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.

PART 2

Who is organising and funding the study?

The organisation and funding of the project is carried out by WMG.

What will happen if I don't want to carry on being part of the study?

Participation in this study is entirely voluntary. Refusal to participate will not affect you in any way. If you decide to take part in the study, you will need to sign a consent form, which states that you have given your consent to participate.

If you agree to participate, you may nevertheless withdraw from the study at any time without affecting you in any way. However, after recording the interview, if you feel the need to withdraw, you can contact the investigator to inform your withdrawal without any explanations. Your records or information will be deleted and not used in any part of the research. In the case of no withdrawal request made after 6 weeks of the interview, the investigator will use the data in an anonymised format in the research.

You have the right to withdraw from the study completely and decline any further contact by study staff after you withdraw.

Who should I contact if I wish to make a complaint?
Any complaint about the way you have been dealt with during the study or any harm you might have suffered will be addressed. Please address your complaint to the person below, who is a senior University of Warwick official entirely independent of this study:

Head of Research Governance
Research & Impact Services
University House
University of Warwick
Coventry
CV4 8UW
Email: researchgovernance@warwick.ac.uk
Tel: 024 76 522746

Will my taking part be kept confidential?

Will maximise encrypting identifiable data;
Will remove face sheets containing identifiers (e.g., names and addresses) from survey instruments containing data after receiving from study participants;
Properly dispose, destroy, or delete study data / documents;

Will limit access to identifiable information for people not involved in research;
Securely store data documents within university secure servers

What will happen to the results of the study?

After the study, the participants will be invited to attend a dissemination workshop and the results will be presented to them in a scientific context. There are possibilities in the future to publish these results in a journal but with consensus with the participants.

Who has reviewed the study?
This study has been reviewed and given favourable opinion by the University of Warwick's Humanities and Social Science Research Ethics Committee (HSSREC):

What if I want more information about the study?
If you have any questions about any aspect of the study, or your participation in it, not answered by this participant information sheet, please contact:

Mr. Rajesh Shankar Priya
Eng-D Candidate,
WMG, University of Warwick, Coventry, CV4 7AL
Tel: +44 7488277843

Academic Supervisor

Professor Janet Godsell
Professor of Operations and Supply Chain Strategy
WMG, University of Warwick, Coventry, CV4 7AL
Tel: +44 (0) 2476 573482

Thank you for taking the time to read this Participant Information Sheet.

9.3 Case Study Database TATA Steel

Case Study: Summary of Key Documents

ID= Initial Discussion, TF= Telephone Conference GD= Contact Notes from Group Discussions

Note:
This list only corresponds to primary data sources. The secondary data sources are listed in the relevant contact notes forming a chain of evidence.

Date and Location	**Ref**	**Interviewee**	
		Name	***Role***
10.11.2017 **TS Head Office Llanwern**	ID#1	SW	Director SC Fulfilment
20.03.2018 **Telephone Conference**	TF#1	MA	Head of SC Fulfilment
24.04.2018 – 26.04.2018 **TS Head office, Llanwern, UK**	GD#1	MA	Head of SC Fulfilment
	GD#2	JP	Customer Service Team
	GD#3	CJ	Customer Service Team
	GD#4	CL	Automotive Replenishment Manager
	GD#5	AD	Manager Weekly S&OP
	GD#6	MR	Design Lead
	GD#7	HH	Replenishment Controller
	GD#8	CM / SF	Scheduling Manager & Process Lead
	GD#9	SW	Director Fulfilment

9.4 Case Study Database JLR

JLR

Date and Location	Ref	Interviewee	
		Name	***Role***
06.11.2017 **JLR Castle Bromwich**	ID#1	MS	Manager Technology
27.11.2017 **JLR Halewood**	ID#2	RA	Manager Order Fulfilment
13.07.2018 **JLR Halewood**	FW#1	AT, NC	Production Planning Manager
19.05.2018 **WMG, Warwick**	W#1	WMG, JLR, TATA	All Key Stakeholders
24.07.2018 **JLR Halewood, UK**	GD#1	MS	Manager Technology
	GD#2	AT	Production Planning Manager
26.09.2018 **WMG, Warwick**	W#2	WMG, JLR, TATA	All Key Stakeholders

Case Study: Summary of Key Documents

ID= Initial Discussion, FW= Field Visit GD= Contact Notes from Group Discussions, W= Joint Workshops for Dissemination

Note:
This list only corresponds to primary data sources. The secondary data sources are listed in the relevant contact notes forming a chain of evidence.

9.5 Contact Notes TATA Steel

TATA Scoping Study - Contact notes (GD#1)

Interviewee	Steve Wixey	Transcript No.	ID# 1
Job Title	Director of Supply Chain Fullfillment	Date	10.11.2017
Contact Details	Director Fulfilment Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 E: steve.wixey@tatasteel.com www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Worked in SC for over 20 years.
- He recently took over the Director Position from his predecessor "Matt Yeates" who was in close contact with WMG
- He was extremely inquisitive during the session and wanted to test the interviewer with a lot of technical questions relation to Supply Chain productivity topic.
- He was direct and wanted actionable progress objectives.
- On delivering him an objective list which enhances TS current supply performance, he guaranteed access to all department within TS

2.0 Main themes or Issues arising

Long standing supply performance issues with JLR

- TS'S "Make to Forecast" calculation is not in alignment with the actual orders for the past few years.
- TS reacts to wrong demand signals from JLR, affecting the performance of entire SC.
- However, TS has been responding to the requirements despite the variation of demand, but the customer is not that satisfied with the efforts.
- TS's objective is not only to over the supply performance but in future want to be JLR's champion customer.
- TS strategically values all its automobile customers including JLR, Nissan, Reno.

Critical Review Meeting with JLR in early 2018 to underline the issues

- TS is expected to meet with key managers in JLR to discuss future collaboration and the current scenario is not that favourable.

- There is an urgent need for better collaboration and TS requires support from WMG to provide a practical/pragmatic plan with some Enabler and Inhibitor Analysis based on their current processes.

Technical Insights from Demand Management and Planning

- TS's has not completely understood while forecasting on why there is a significant variation in demand
- There is a "Binary" schedule agreement in place but consistently responding the requirements has been a consistent challenge.
- The Demand planning team is curious to know more on "What changes the bill of schedule" from the JLR side?
- What is the reason for the forecasting discrepancy (consumption details from JLR, not in alignment with TATA's forecasting plan)?
- What causes demand variation with in the customer?
- What are the key capabilities required to solve the demand variations in the supply chain?

3.0 Summary of Information Gathered

- **TS** produces over 75000 Metric Tonnes of Steel every week.
- The key automobile customers for TS are JLR/Nissan/BMW/Nissan and RENO
- 10% of steel production is aimed towards automobile sectors
- The critical aspect of business is "Demand Planning"

4.0 other Salient, interesting, illuminating or important aspects

- As Nissan is also another key customer of TS, there seems to be a better demand planning mechanism in place.

5.0 new/outstanding questions for next visit

- It has been agreed that TS provides a 3-day data collection workshop in early Spring 2018 with the key personnel from the order-fulfilment, demand planning and management team.

6.0 references

None

7.0 supporting documents

Not Identified.

TATA Scoping Study - Contact notes (TF#1)

Interviewee	Mark Abramo	Transcript No.	TF# 1
Job Title	Head of Supply Chain Fullfillment	Date	20.03.2018
Contact Details	Head of Fulfilment Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 E: steve.wixey@tatasteel.com www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Worked in SC for over 25 years.
- Leading a team of 20 people in UK and 25 people off-shore in India, Kolkatta
- Extremely friendly during the conversation.
- He was initiated by Steve Wixey to lead this project and guaranteed access to all department within TS during the field visit

2.0 Main themes or Issues arising

A brief introduction on JLR's order and planning process

- He/His team can oversee 26 weeks of overall demand fed in to the SAP system by the customer (JLR)
- 10-14 weeks' time required in production for FG.
- The Forecasts are based on part levels for JLR.
- 40 SKUs are set for JLR.
- There are a number of different processes involved in transforming demand to real production planning.
- A detailed outlook will be provided during the field visit in April 2018.
- There is a colouring system (mechanism) in place to read the status of stocks.
- There are no SLA's in place with JLR

Questions regarding accessing Key Personnel during the Field Visit in April 2018

- MA wanted to know more details on the field visit planned for April 2018
- What team needs to be present for the field visit
- How long the visit if planned for?
- What kind of quantitative data is required for the purpose of the research?
- Who will be attending the field work

3.0 Summary of Information Gathered

- MA Provided a set of raw data on JLR's order pattern for the past 24 months

- The data also included the forecast details of the parts and the actual orders invoiced to the customer

4.0 other Salient, interesting, illuminating or important aspects

- There are a number of different processes at TS
- In order to understand the processes, an elaborate study is required
- TS very keen to understand the customer's SC and decoupling points.

5.0 new/outstanding questions for next visit

- A detailed agenda for the meeting will be sent to MA and his team in order to prepare for the field work
- It is highly likely that two external companies will accompany during the field work to strengthen the collaboration of this project
- Ethical approval forms are required to be signed before the field visit.

6.0 references

None

7.0 supporting documents

Not Identified.

TATA Scoping Study - Contact notes (GD#3)

Interviewee	Claire Jones	Transcript No.	GD# 3
Job Title	Customer Service Lead for JLR Operations	Date	24.04.2018
Contact Details	Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Works under MA's direction
- Responsible for JLR Operations

2.0 Main themes or Issues arising

Key Parameters for Service

- Service is the key focus for the customer service team.
- There is a daily meeting to check the customer requirements.

Key Issues

- Too many contact points.
- Too many different perspectives with respect to maintaining
- The overall approach is reactional.
- Some collaboration measures exist but not widely understood across the company.
- No contractual SLA's exist.
- There is a daily review meeting in place.

3.0 Summary of Information Gathered

- There is a contact map for JLR. (Still pending approval to share this information.

4.0 other Salient, interesting, illuminating or important aspects

None

5.0 new/outstanding questions for next visit

None

6.0 references

None

TATA Scoping Study - Contact notes (GD#4)

Interviewee	Christopher Lonergan	Transcript No.	GD# 4
Job Title	Automotive Replenishment Manager	Date	24.04.2018 & 25.04.2018
Contact Details	Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Has over 15 years of SC experience.
- Worked at different functions at TS.
- Currently work lead a team of 7 people.

2.0 Main themes or Issues arising

Data Management

- Demand Data from all companies including JLR is collected by a group (transformation group).
- That data is processed on a stand-alone application developed by key personnel in the group (STEVE H WILLIAMS).
- Steve doesn't look on individual demand signals from companies but takes all demand signals and optimises them with the capacity of "slab".
- The reason being "1200 SKUs" to deal with.
- it is difficult to segment single demand.
- There is a clustering process involved.
- Steve performs a mathematical test in correlation to the slab.
- E.g with an order for 9 tonnes, slab requires 22 tonnes.
- My team involves in batching the demand with respect to the capacity constraints.
- We also draw a pattern of orders.
- Our team deals with the planned orders and the scheduled orders.
- The actual orders are reviewed on a daily basis

Key Issues

- We are over dependent on Steve's data
- In case of absence of ley personnel, it is extremely difficult to coordinate.
- The SAP system is a "nice to have" tool, however, for actual demand planning, I have developed a standalone excel tool for better analytics.
- There is no live reporting tool.
- The factory planning is not defined on how it works.

- The constraint with JLR is that order freezing time is just 4 weeks in comparison to 7 weeks with Nissan.
- The variability of demand is so unpredictable.
- Most of the tools are built by own team members.
- SAP needs to be fully integrated.
- There are concerns on the stability of our data feeding mechanism.
- There are no live updates on SAP with order management (occurs only on a daily basis!!)

3.0 Summary of Information Gathered

- CL has provided “Concentra” 2 years of JLR’s historic data on actual consumption vs forecast.

4.0 other Salient, interesting, illuminating or important aspects

- This team is critical in demand planning. However, there are no backup’s and most of the demand management were done using methods which were developed individually.
- Why would they not integrate those tools in the mainstream SAP?

5.0 new/outstanding questions for next visit

None

6.0 references

None

7.0 supporting documents

Not Identified.

TATA Scoping Study - Contact notes (GD#2)

Interviewee	Johanne Par	Transcript No.	GD# 2
Job Title	Customer Service Lead for JLR Operations	Date	24.04.2018
Contact Details	Head of Order Management and Fulfilment Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 E: steve.wixey@tatasteel.com www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Works under MA's direction
- Responsible for JLR Operations

2.0 Main themes or Issues arising

Key Parameters for Service

- Service is the key focus for the customer service team
- There is an elaborate chart for key communication personnel with JLR.
- That list is extremely polluted with over 100 contact points within JLR
- However, we just contact only a few of them regularly.
- Our team Deals with all purchases for JLR.
- There is a structured customer relationship process within TS.
- There is also an Escalation process within the team in case of customer requests.
- JLR has its own measure to measure the performance.

Key Issues

- Too many contact points.
- Too many different perspectives with respect to maintaining
- We are involved in a lot of "Reactive Heroics" process management with JLR.

3.0 Summary of Information Gathered

- There is a contact map for JLR. (Still pending approval to share this information.)

4.0 other Salient, interesting, illuminating or important aspects

TATA Scoping Study - Contact notes (GD#1)

Interviewee	Mark Abramo	Transcript No.	GD# 1
Job Title	Head of Supply Chain Fullfillment	Date	24.04.2018
Contact Details	Head of Order Management and Fulfilment Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 E: steve.wixey@tatasteel.com www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Worked in SC for over 25 years.
- Leading a team of 20 people in UK and 25 people off-shore in India, Kolkatta
- Had a brief Telephone Conference late March to initiate the field work

2.0 Main themes or Issues arising

TS's core business

- Steel production of around 75000 Tonnes/Week
- It is produced mostly as coils which weighs from 12-30 tonnes and 6 fool tall and wide.
- 25000 tonnes of steel are produced for various inter business needs.
- 10000 tonnes are produced for engineering businesses (mainly for Radiators and Drums).
- 7000 tonnes per week are allocated for customers in automotive sectors like (JLR/BMW/NISSAN and RENO).
- The strategy for TS is to increase automotive portfolio.
- Quality inspection is done at all stages.
- There are 2 lines of inspection (standard coil line and automotive finishing line).

Role of Order Fulfilment Team

- Cradle to Grave solutions provided.
- 65-70% of productions are handled by MA's team.
- The order fulfilment team is responsible for the design and maintenance of order fulfilment strategies linked to end user/sector requirements.
- The acceptable lead times, service levels, manufacturing reliability, feasibility and affordability are all set by this team.

- The different types of order fulfilment strategies are MTO, MTF, MTA and FTO.
- All planning activities (weekly/monthly) planning activities are planned at LLanwern site.
- The most critical aspect is “Demand Forecasting”.
- The team is also responsible for the deployment of MRP systems and materials expedition processes based on the “Theory of Constraints”.
- The team is also responsible for dynamic buffer management (pipeline/ decoupling stock level)
- This is directly correlated to the order fulfilment strategy and the colour coding assigned is based on the “Theory of Constraints”.

IT Platforms

- There are several IT platforms in place
- The backbone platform is based on SAP.
- RAPID is a data reporting system.
- Factory Planner (FP) converts orders in to a production plan
- DILO is a system used to refresh data on a daily basis (as no live data feeds are available).
- BRONER facilitates sequential production planning.
- STACCA and COMPASS are MES systems.
- All ordering and execution processes are performed in SAP.
- There was a recent 100-million-pound investment on SAP development

Order Management

- TS has an order prioritisation system based on an assigned colour in order to achieve throughput optimisation as well as to minimise inventory and operating expense.
- A colour code will demonstrate a uniform impact on the customer or the next process.
- Orders normally fall in to 2 categories: 1) orders which replenish a decouple point (MTA/MTF). These orders are coloured based on principle of buffer penetration. 2) orders which are linked directly to a customer order (MTO/FTO). These orders are coloured based on lead time penetration.

- For MTF Decoupling points the colours will be allocated based on the amount of the stock at a specific decoupling point compare against the number of weeks it can cover future demand (actual orders and schedule agreements).
- MTF replenishment orders are coloured based on the projected net stock positions at the moment in time the order is planned to arrive at the decouple point.
- For MTA decoupling points, the colours will be allocated based on the amount of stock at a decouple point compared against the total pipeline target.
- MTA replenishment orders are coloured based on projected net stock, reduced by the actual average demand.

- MTO lead time penetration is based on delta between due date and the minimum completion time.
- TS has over 120000 tonnes of arrears in orders in 2017.
- The arrears for 2018 is 30000 Tones and the target is 25000 in 2019.
- This is still best in the steel industry.

3.0 Summary of Information Gathered

- Information required to perform a value stream mapping of the entire TS-JLR direct supply.

4.0 other Salient, interesting, illuminating or important aspects

- There is a demand transformation group, which interprets demand information and manually adjust in SAP.

5.0 new/outstanding questions for next visit

- Several individual workshops are planned with team dealing with JLR during the visit

TATA Scoping Study - Contact notes (GD#5)

Interviewee	Adrian	Transcript No.	GD# 5
Job Title	Manager Weekly S&OP	Date	25.04.2018
Contact Details	Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Has over 20 years of SC experience.
- Worked at different functions at TS.
- Head the S&OP team Responsible for mainland EU

2.0 Main themes or Issues arising

Highlights of S&OP

- There are various account managers in the team (dealing with specific customers) who pull the latest forecasts from customers.
- They gather all the data and submit the forecast to SAP.
- They do a historic pattern check on the forecasts they receive.
- The team also performs a scoring model on listing the premier customers.
- The scoring is based on principles of revenue, strategic importance, total number of orders.
- Automotive customers are ranked higher.
- The S&OP team commits a specific number of tons per week to Automotive customers (around 7000 Tons).
- The planning is performed by a software provided by the company JDA.
- There is a monthly make plan and a sale plan.
- The entire demand for a quarter is considered.
- Then the team splits the demand in weeks in correlation to the weekly capacity constraints.
- Weekly plans for 26 weeks of orders are made.
- There are up to 3 years of monthly planning available at any given time
- The entire automotive customers orders are made by a “Make to Forecast” method.
- The replenishments are based on orders that are of priority.
- Make to forecast is the absolute priority.
- This is because the customers are important, and the products are of higher value.

- The make to order will be tuned (cut if necessary) according the booking orders of MOF.
- The calls will be made by the demand planners/

Key Metrics

- Operational effectiveness is measures by the amount of arrears.
- Capacity forecasting for 3 years
- OTIF is the priority.
- Capacity alignment with orders (However, most of the time, the forecasts does not go through capacity checks).
- Standardized review techniques.
- Not to “oversell” products.
- Regular reviews on stock targets (weekly basis)

Safety Stock Approach

- SKUs are ranked based on performance.
- There is a SKU ranking dashboard
- All stocks are allocated by colour coding mechanism.
- Black and red denotes to a negative stock (Red for missing customer requirements, black for stock out), while Green and blue denotes to a more stocks (over 5 weeks0. The optimal colour is Amber (less than 5 weeks of stocks).
- The yields are calculated for individual SKUs.
- There are limited documentation procedures.
- There is a weekly scheduling mechanism to investigate any changes in the orders.
- Yield data is incorporated in the safety stocks.

3.0 Summary of Information Gathered

- CL has provided “Concentra” 2 years of JLR’s historic data on actual consumption vs forecast.

4.0 other Salient, interesting, illuminating or important aspects

- The advanced analytics for forecasting seem to work well
- The team evaluates a good selling capacity and not involves in overselling.
- The service is measured by OTIF delivery.
- There is a good sense of planning.

5.0 new/outstanding questions for next visit

TATA Scoping Study - Contact notes (GD#7)

Interviewee	Hannah	Transcript No.	GD# 7
Job Title	Replenishment Controller	Date	26.04.2018
Contact Details	Strip UK Supply Chain **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Works in the team of CL
- Managed around 400 SKUs
- Overseas replenishment for JLR.
- The team releases orders based on project demand

2.0 Main themes or Issues arising

Key Issues

- There are 21 weeks of available data at RAPID at SKU level.
- RAPID projects customer requirements taken from the forecasts.
- As many systems interface, there is always an issue of reliability.
- There is a “Broken Chain” problem due to this issue.
- The MRP process has some issues with defining the actual slab status.

3.0 Summary of Information Gathered

- Scheduling Information.
- A short description on Factory planner

4.0 other Salient, interesting, illuminating or important aspects

- There is no live reporting tool
- They work on a standalone application developed by the team members despite the SAP.

TATA Scoping Study - Contact notes (GD#8)

Interviewee	Chris May and Scott Foreword	Transcript No.	GD# 8
Job Title	Scheduling Manager & Process Lead	Date	26.04.2018
Contact Details	Port Talbot SA13 2NG **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 www.tatasteeleurope.com	Location	Telephone Conference from TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Heads the scheduling department at Port Talbot
- Worked at several functions at TS.
- Overseas all scheduling for TS

2.0 Main themes or Issues arising

Scheduling Process

- The team receives a dumb plan from the demand planning.
- The team has a good control on material flow and planned
- The manufacturing process is initiated by casting the materials at the required order.
- There are quality constraints from automotive customers
- They are well documented in the quality management protocol.
- The demand is placed based on a weekly plan.
- The required plan is replicated in the scheduling system.
- The scheduling system is “BRONER”.
- BRONER performs physical scheduling
- A manufacturing plan is then released
- Production is than placed on the scheduler.
- The measure of success for the team is based on complaint scheduling.
- There is a manufacturing meeting every meeting which overlooks the weekly performance.
- There are very few cancellations of scheduling process

3.0 Summary of Information Gathered

- The entire chain of scheduling process
- ZODIAC-SAP-FP-BRONER-DYLO-RAPID

4.0 other Salient, interesting, illuminating or important aspects

- There is a robust team with excellent daily management process

- The team exceptionally handles well with the flow of information
- Despite the demand variability, they do not chop and change the system.
- Exceptional control on scheduling.
- They have a good plan to expedite (priority management).
- They are pioneers in building links between manufacturing units and production planners.
- Close working relations
- They have regular internal conversations and numerous debates.
- Due to the stability of the data feed, they again have a stand-alone application developed by their team members to overcome the problem.
- There is a good balance of local optimisation with system flow.
- They maintain a flexible schedule horizon with a 3-day window.
- The weekly scheduling production schedules are based upon sequencing rues.
- A better demand signal will be a definite boost

5.0 new/outstanding questions for next visit

None

6.0 references

None

7.0 supporting documents

Not Identified.

TATA Scoping Study - Contact notes (GD#9)

Interviewee	Steve Wixey	Transcript No.	GD# 9
Job Title	Director Supply Chain	Date	26.04.2018
Contact Details	TS Head Quarters, LLanwern, UK **Tata Steel** T: +44 (0)1633755229 M: +44 (0) 7764836352 www.tatasteeleurope.com	Location	TS Head Quarters, LLanwern, UK

1.0 Interviewee background

- Second conversation with Steve Wixey

2.0 Main themes or Issues arising

Requirements from this study

- It is vital to study the supply chain of JLR
- JLR uses different steel parts for cars and it is important to list them.
- Minimise understocking (do we have the right quantity are we reacting at the right location)
- We are interested to enhance our lead time stability.
- Service is the key for TS.
- Clean “Demand Signals” a vital requirement for the entire SC.
- Actionable result is expected from this study

3.0 Summary of Information Gathered

4.0 other Salient, interesting, illuminating or important aspects

- **Actionable results required for the projects**

9.6 Case Study Notes JLR

Die to confidentiality issues, JLR requested not to publish the case study notes in a public document.

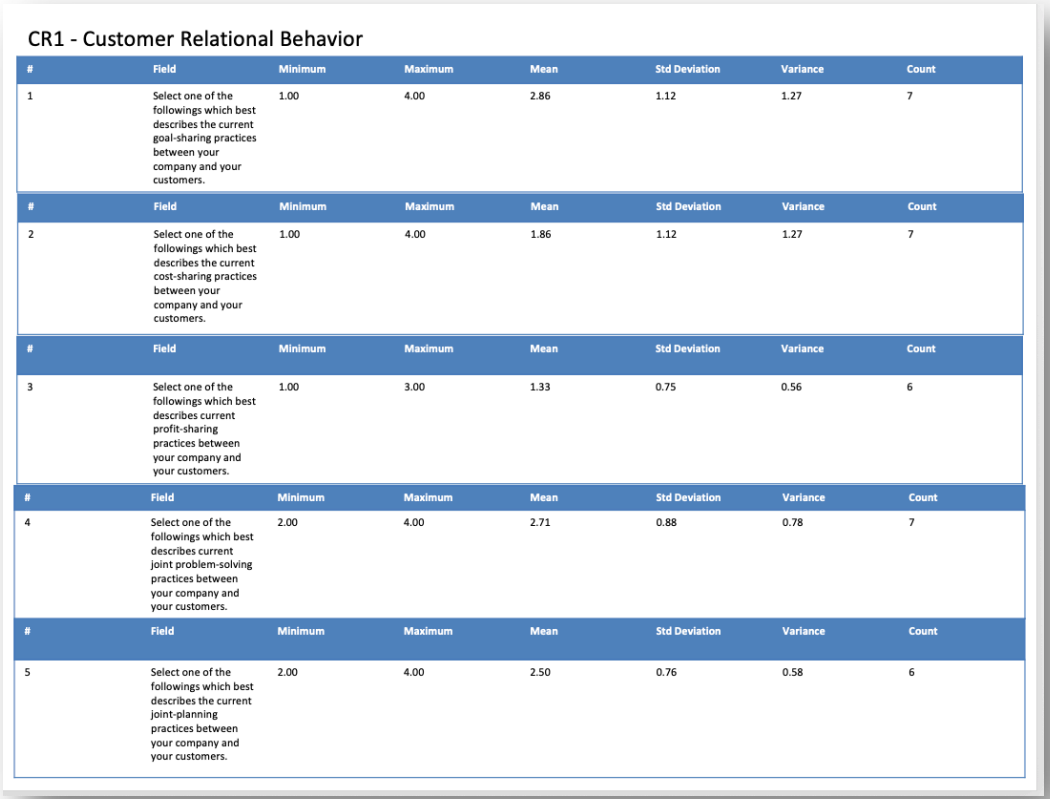
9.7 E&I Analysis Data

OS1 - Organization Block

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Which of the following activities are under the control of the operations/ supply chain director (or equivalent) in your company? [Plan] [Source] [Make] [Delivery] [Sales]	2.00	4.00	3.13	0.78	0.61	8
2	In your company, there are process owners for each of the following core business processes - Plan, Source, Make, Delivery and Sales	1.00	4.00	2.00	0.87	0.75	8
3	In your company, employees have cross-functional knowledge and skills required to manage the core business process including Plan, Source, Make, Delivery and Sales	2.00	4.00	2.50	0.71	0.50	8
4	In your company, departments are organised according to the following core business processes - Plan, Source, Make, Delivery and Sales	1.00	4.00	2.13	0.78	0.61	8
5	In your company, employees are frequently involved in task forces or interdepartmental activities.	2.00	4.00	2.63	0.86	0.73	8

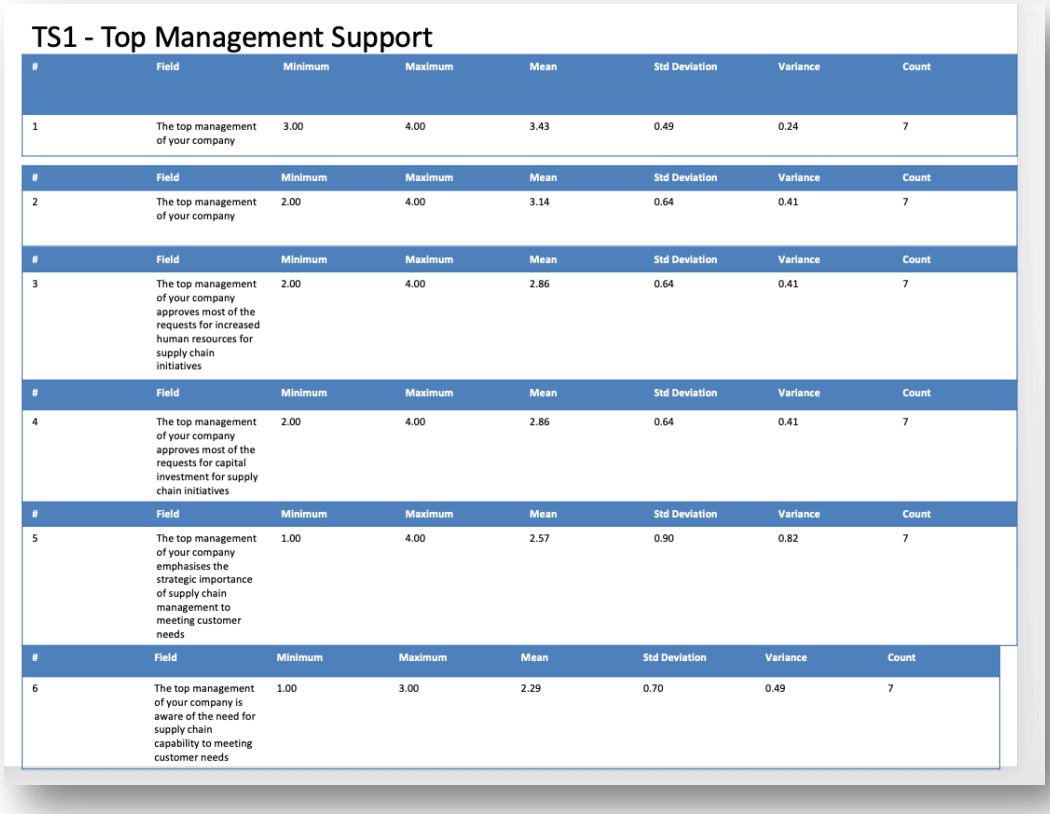
IR1 - Internal Relational Behavior

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Select one of the following which best describes the average employee involvement in cross-functional activities in your company	2.00	5.00	3.43	1.05	1.10	7
2	Select one of the following which best describes the current level of mutual understanding in your company	2.00	3.00	2.71	0.45	0.20	7
3	Select one of the following which best describes the current joint problem-solving practices in your company?	2.00	4.00	3.00	0.58	0.33	6
4	Select one of the following which best describes the current joint-planning practices in your company?	2.00	4.00	2.71	0.70	0.49	7



CR1 - Customer Relational Behavior

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Select one of the followings which best describes the current goal-sharing practices between your company and your customers.	1.00	4.00	2.86	1.12	1.27	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	Select one of the followings which best describes the current cost-sharing practices between your company and your customers.	1.00	4.00	1.86	1.12	1.27	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	Select one of the followings which best describes current profit-sharing practices between your company and your customers.	1.00	3.00	1.33	0.75	0.56	6
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	Select one of the followings which best describes current joint problem-solving practices between your company and your customers.	2.00	4.00	2.71	0.88	0.78	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
5	Select one of the followings which best describes the current joint-planning practices between your company and your customers.	2.00	4.00	2.50	0.76	0.58	6



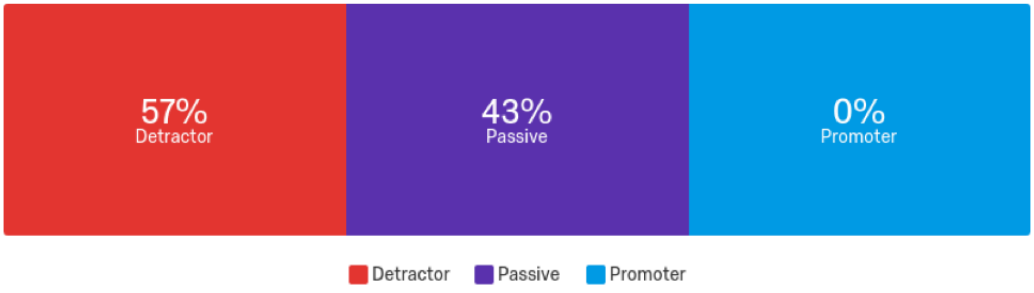
TS1 - Top Management Support

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The top management of your company	3.00	4.00	3.43	0.49	0.24	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	The top management of your company	2.00	4.00	3.14	0.64	0.41	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	The top management of your company approves most of the requests for increased human resources for supply chain initiatives	2.00	4.00	2.86	0.64	0.41	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	The top management of your company approves most of the requests for capital investment for supply chain initiatives	2.00	4.00	2.86	0.64	0.41	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
5	The top management of your company emphasises the strategic importance of supply chain management to meeting customer needs	1.00	4.00	2.57	0.90	0.82	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
6	The top management of your company is aware of the need for supply chain capability to meeting customer needs	1.00	3.00	2.29	0.70	0.49	7

IS1 - Information Sharing

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The information available to the operations/supply chain department is relevant to the management of material flow	1.00	4.00	2.00	0.93	0.86	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	The information for the management of material flow required by the operations/supply chain department is accurate	2.00	4.00	3.00	0.76	0.57	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	The information for the management of material flow required by the operations/supply chain department is available in a timely manner	2.00	4.00	2.71	0.88	0.78	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	The information for the management of material flow required by the operations/supply chain department is sufficiently available	2.00	5.00	3.00	1.20	1.43	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
5	The operations/supply chain department has sufficient knowledge to use all available information for the management of material flow.	1.00	4.00	2.57	1.05	1.10	7

PM5 - Please check one of the numbers below to indicate the effect of the business performance measurement system to the employee behaviour?



PM1 - Business Performance Measurement Systems

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The performance targets at different organisation levels are linked to the overall business objectives	1.00	4.00	2.14	0.99	0.98	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	The performance of different organisation levels is reported at agreed intervals	1.00	4.00	2.29	0.88	0.78	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	The performance of different organisation levels is reviewed against targets at agreed intervals	1.00	4.00	2.29	0.88	0.78	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	When the performance targets are not met, your company takes action to improve the performance	2.00	4.00	2.86	0.99	0.98	7

SA1 - Shareholder Alignment

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The business strategy of your company is consistent with the objectives of shareholders/owners	2.00	6.00	3.00	1.41	2.00	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	The supply chain/operations strategy of your company is consistent with the business strategy	1.00	5.00	2.57	1.29	1.67	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	The employees of your company share the same vision with the shareholders/owners	2.00	6.00	3.71	1.58	2.49	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	When the supply chain cannot deliver shareholder/owner objectives, your company initiates necessary changes to processes and the organisation	2.00	4.00	2.86	0.83	0.69	7

CA1 - Customer Alignment

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The business strategy of your company is consistent with customer needs	2.00	4.00	2.86	0.83	0.69	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	Select one of the following which best describes the performance of the supply chain/operations strategy of your company	3.00	4.00	3.57	0.49	0.24	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	Your company willingly adjusts its operations to fulfil the different needs of key customers	1.00	4.00	1.86	0.99	0.98	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	When the supply chain cannot fulfil customer needs, your company initiates necessary changes in processes and organisations	1.00	4.00	2.57	1.05	1.10	7

BP1 - Business Performance

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	During the last five years, the net profit of your company has	2.00	3.00	2.43	0.49	0.24	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	During the last five years, the revenue targets of your company has	2.00	3.00	2.43	0.49	0.24	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
3	During the last five years, the revenue targets of your company has	2.00	3.00	2.43	0.49	0.24	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
4	During the last five years, the return on investment (or capital employed) of your company has	1.00	3.00	2.29	0.70	0.49	7

D1 - Supply Chain Strategy Orientation

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Please indicate the focus of the business strategy of your company in terms of sales growth and cost reduction	3.00	5.00	3.57	0.73	0.53	7
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
2	Please indicate the focus of the business strategy of your company in terms of fulfilling customer needs, fulfilling shareholder objectives or the balance between them	1.00	4.00	2.86	0.83	0.69	7

9.8 SKUs based on RRS Classification

RRS Classification

SKU	RRS Criteria	Category Runner = Variance < 100 %, Order in > 80% of weeks Repeater = Variance < 200 %, Order in > 30% of weeks Stranger = Variance > 200 %, Order in < 30% of weeks	Demand Type	Coefficient of Variation	Average Demand Frequency
HW329	62%	Runner	Erratic	43%	33%
HW313	62%	Runner	Smooth	28%	36%
HW314	69%	Runner	Smooth	21%	49%
HW397	96%	Runner	Smooth	38%	46%
HW492	96%	Runner	Smooth	39%	46%
HW507	110%	Repeater	Erratic & Intermittent	57%	74%
HW506	112%	Repeater	Erratic & Intermittent	51%	74%
HW305	129%	Repeater	Erratic & Intermittent	55%	79%
HW387	131%	Repeater	Intermittent	35%	60%
HW479	133%	Repeater	Erratic & Intermittent	60%	51%
HW497	140%	Repeater	Intermittent	32%	50%
HW300	143%	Repeater	Erratic & Intermittent	56%	33%
HW373	144%	Repeater	Smooth	17%	47%
HW499	144%	Repeater	Smooth	16%	39%
HW415	147%	Repeater	Erratic & Intermittent	43%	84%
HW391	148%	Repeater	Erratic & Intermittent	45%	39%
HW500	152%	Repeater	Smooth	34%	44%
HW240	154%	Repeater	Erratic & Intermittent	43%	63%
HW409	165%	Repeater	Erratic & Intermittent	52%	90%
HW219	166%	Repeater	Smooth	11%	42%
HW394	167%	Repeater	Intermittent	37%	94%
HW222	168%	Repeater	Erratic & Intermittent	61%	78%
HW414	169%	Repeater	Intermittent	40%	96%
HW519	169%	Repeater	Smooth	75%	32%
HW521	169%	Repeater	Smooth	3%	47%
HW520	174%	Repeater	Smooth	23%	47%
HW498,	183%	Repeater	Intermittent	38%	56%
HW435	202%	Stranger	Intermittent	39%	62%
HW555	254%	Stranger	Intermittent	38%	61%
HW457	354%	Stranger	Intermittent	38%	65%
HW264		Stranger			

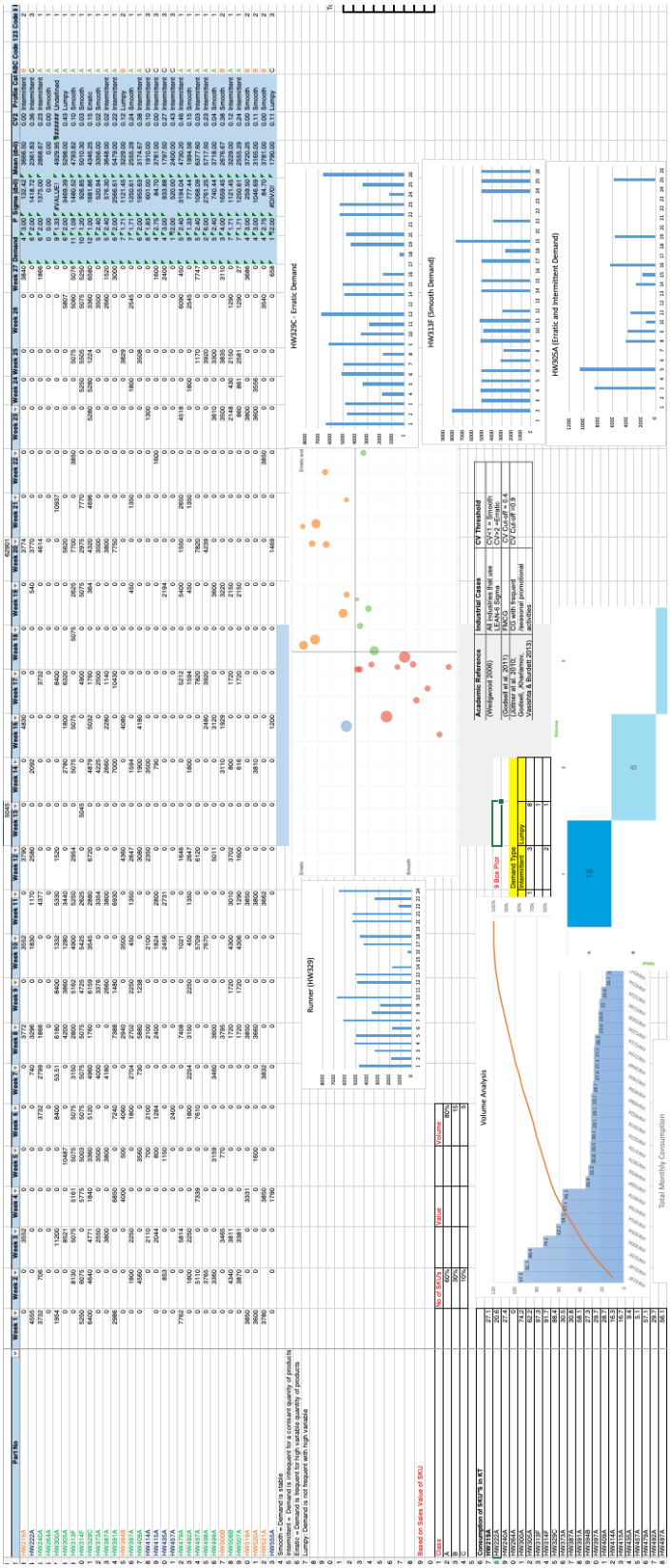
9.9 Maturity Assessment Topics and Questionnaire based on (Crimson 2017)

Planning Phase	Topic	Questions
S&OP	Policy	1) How is the process documented? 2) Do you have a define scope with inputs from all the participants? 3) Do you have an agenda for every meeting? 4) Is there any review process after every quarter?
S&OP	Process	1) Do you circulate the meeting dates in advance? 2) Are there any standard set of documents for saving protocols? 3) Do you integrate the demand and supply management in the planning process? 4) Do you have a single operation plan? 5) Do you review the key decisions? If yes, how often?
S&OP	Planning Horizon	1) Do you start the planning with the focus on changes from the previous planning months? 2) How do you define long term and short-term planning? 3) How long the planning horizon extends? 4) Is there any alignment with the previous decisions and reviews?
S&OP	Involvement	1) Who gets involved in the planning? 2) Are the roles of involvement clearly defined? 3) Can they take the key decisions? 4) Do you involve the external departments? 5) Who is involved in external roles? Finance? 6) How to act to issues on previous agreed actions which were not performed?

Phase	Topic	Questions
Run Strategy	Product to Plant	1) How does planning operates in relation to a customer service? 2) How are products aligned in groups? 3) Does the planning team understand the customer service levels or any agreements in place? 4) How is the cost to produce calculated?
Run Strategy	Production Cycle	1) Is there a MOQ limit? 2) Are there any barriers that impact productivity? 3) What is the calculation based on? (Optimizing Production)

Phase	Topic	Questions
FG Inventory MGMT	Inventory Setting	1) Are there are particular circumstances which changes? 2) Inventory Policies differ per product category, such as slow movers, which may be held in fewer locations? Are safety stock levels calculated based on demand variability? 3) Is the inventory balanced through stock transfers as well as replenishment? Stock levels are based on demand and supply variability to achieve CS levels at minimum SC cost? 4) How is the SS level calculated?
FG Inventory MGMT	Stock Accuracy	1) Is accuracy measured at location level? How are the stock checks conducted? (financial points/time). Inventory errors are corrected as they are uncovered 2) Do you have a process to eliminate causes of errors in place? 3) How often is the inventory accuracy calculated?
FG Inventory MGMT	Stock Obsolescence	1) Do you recognize the slow-moving stocks? 2) Do you perform a value analysis on these slow-moving stocks? 3) How to react to shelf-life for the slow-moving stocks? 4) Do you perform any root causes analysis for the slow-moving stocks?
FG Inventory MGMT	Inventory Requirement Planning	1) How is demand plan created? 2) Do you profile your demand based on customers? 3) How is the demand plan distributed? 4) How do you react with unconsumed demand? 5) Do you have a process of inventory handover?

9.10 Excel Tool for Inventory Modelling



UNIVERSITY OF WARWICK

Rajesh Shankar Priya

Enhancing UK Manufacturing Productivity by Enabling a Value Chain Orientation

WMG
Engineering Doctorate Requirements

Engineering Doctorate
Academic Year: 2014 - 2018

Supervisor: Prof. Dr. Janet Godsell
Prof. Dr. Jay Bal

January 2019

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WMG
Engineering Doctorate Portfolio

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Enhancing UK Manufacturing Productivity by Enabling a Value Chain Orientation

Supervisor: Prof. Dr. Janet Godsell
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January 2019

This thesis is submitted in partial fulfilment of the requirements for the degree of Engineering Doctorate
(NB. This section can be removed if the award of the degree is based solely on examination of the thesis)

LIST OF ABBREVIATIONS

Eng-D	Engineering Doctorate
JLR	Jaguar Land Rover
TS	Tata Steel
WMG	Warwick Manufacturing Group

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1 Introduction

The research work and training undertaken during the course of this program provided a fundamental base to the researcher in fulfilling the Eng-D requirements. In this submission, the researcher underpins the official requirements set by the research program and demonstrates on how this has been met.

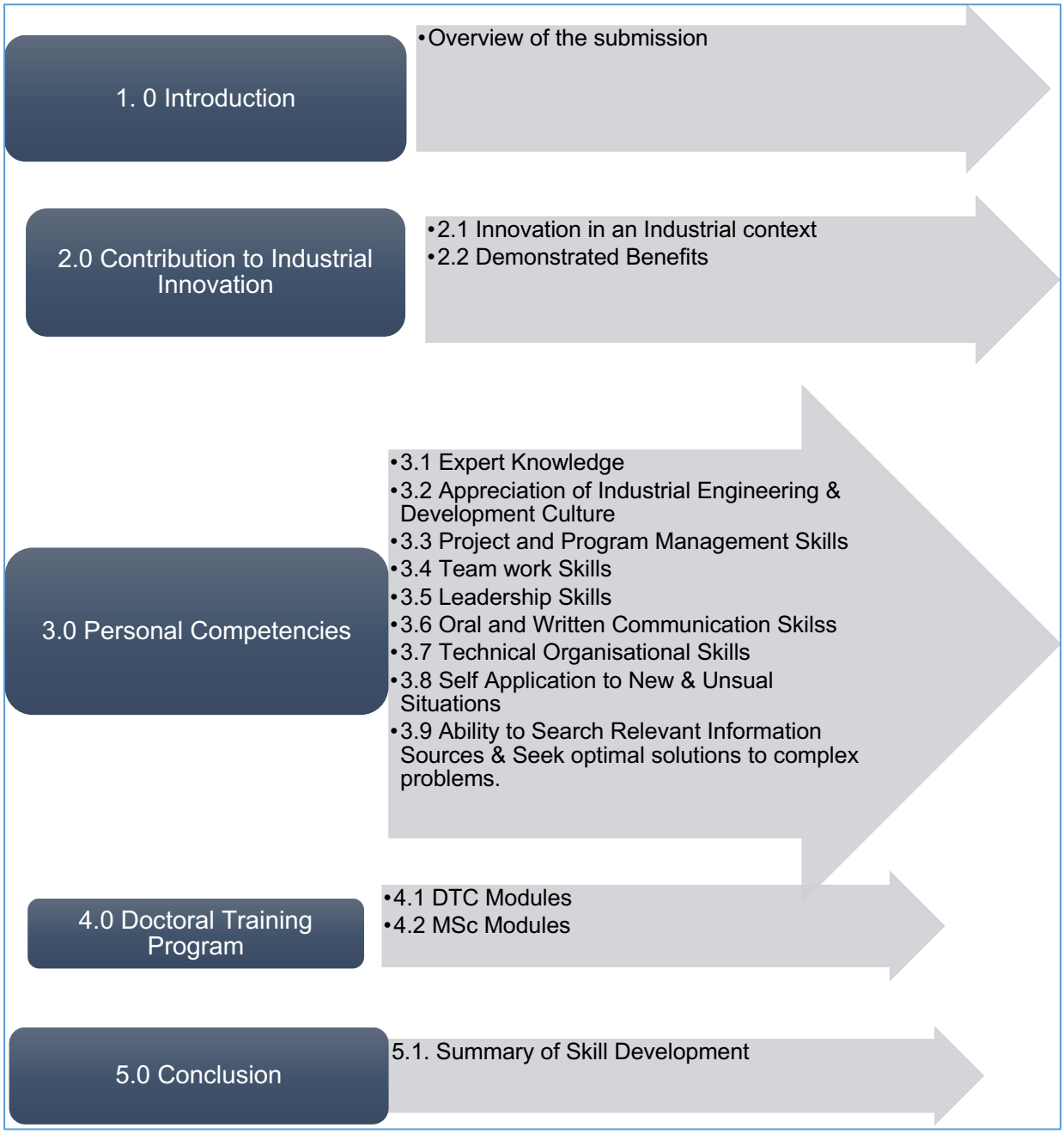

Figure 1: Overview of the Submission

2 Contribution to Industrial Innovation

2.1 Innovation in an Inter-Firm planning context.

This research focuses on improving the productivity of the automotive steel supply chain between JLR and Tata Steel through implementation of an integrated planning process. Prior to this research, companies in automotive steel supply chain were involved in planning independently for demand, supply and inventory processes. This research advocates for an integrated planning process between JLR and Tata Steel that ensures improved availability of material (steel) for the customer, enhancing customer levels at a lower supply chain cost. This research is trialled on an automotive steel supply chain platform between JLR and TS, however the principles of this research could be rolled out to JLR's various steel suppliers and TS's multiple automotive customers. Production stoppages in automotive plants due to shortage of materials causes millions of pounds in loss and the customer service levels dramatically reduce, creating strains in future business relations between suppliers and customers. JLR lost over 20 Million Pounds for the year 2017 due to production stoppages[1]. The concepts developed during this research facilitates improved availability of pressed parts to JLR final assembly sites, minimising loss and at the same time improving customer service. This research has attracted a lot of further attention from the supply chain directors of the involved companies. Based on the outcome of the research, they are in the process of inviting external companies in collaboration with WMG to adapt the framework of this research and build a pilot process within one of the plants at Llanwern, to capture the benefits and extending this research to a larger experiment considering the complexity of the project involving two colossal engineering companies.

2.2 Demonstrated Benefits.

As highlighted in the Innovation Report submission in Chapter 6.2, Table 28, a summary of the key benefits is highlighted in Table 1 of this report.

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1) This was quoted by the Technology Manager at JLR during one of the interviews conducted during this research and has been recorded in a contact note

Table 1: Demonstrated Benefits (Source: Innovation Report))

Innovative Solutions	**Key Benefits**
Demand Segmentation Principles	• Based on the segmentation principles underpinned in the “Innovation Framework” based, four SKU classifications are identified namely: Runner, Repeater, VMI-Repeaters, and Strangers • Two models are identified that can minimize 24 to 30% of inventory
Demand Planning	• Downstream demand is integrated in planning activities • Bespoke delivery strategies for recommended for SKUs based on segmentation (Runners are dispatched directly, Repeaters are dispatched based on forecast and repeaters are dispatched based on orders) • Automatic inventory replenishment • No production stoppage
Synchronized Value Chain	• Steel smelting to meeting gross actual demand. • WIP and Inventory buffers are set by demand volume. • The entire S&OP is set according to the build rate per vehicle. • Demand signal filtered to one source that includes downstream demand • Statistical, Manual forecasting and Automatic replenishment • Armitts as one single inventory
Internal Business Process	• Identification of the key barriers that the overall impact of business. • Detailed assessment of supply, demand and inventory parameters • Joint planning practices between companies. • Various review modalities like weekly, monthly and quarterly r that focus on planning.

3 Personal Competencies

3.1 Expert Knowledge in the field of Automotive Steel Supply Chain Engineering.

The researcher has an engineering background in Aerospace and Robotics before commencing this research. This research however required specific set of engineering and management expertise to identify manufacturing and process capabilities within the supply chain of two traditional engineering companies. The researcher gained expertise knowledge in reviewing core practices of manufacturing not only by bibliographical research and theories associated but also gaining significant knowledge by visiting the core teams of material planning, manufacturing processes and supply chain design, leading to a deep understanding of engineering practices required for an automotive supply chain design. The competences gained during this study were achieved by doing some of the actions listed below:

1) Literature review in Manufacturing Strategy.
2) Frequent industrial visits to understand the current state of art leading to their supply chain design process.
3) Participating and successful completion of MSc modules with distinction in new product design and development.
4) Interaction with technical experts within TS and JLR who are responsible for the engineering processes.

3.2 Appreciation of Industrial Engineering and Development Culture.

The firms involved in this research are innovative in engineering not only in the UK manufacturing context but have a strong development culture globally in promoting “Industrial Engineering Innovation”. The research developed was appreciated by the senior management team and was prioritized within teams like process management and supply chain design at TS. During the course of the research, the directors of the concerned departments often participated in discussions that often-included senior managers who can successfully adapt the working environment based on the findings

of the result. To provide an example, TS and JLR are involved in performing the pilot as a larger scale experiment beyond this research with WMG and other consulting companies. Such pro-active actions of the respective companies provided the researcher an opportunity to understanding the dynamic culture of companies in research innovation and apprehend the process of developing the industrial process of research to applied business solutions. In addition, the researcher has gained competence in Industrial Engineering by visiting, observing and involving in field trips with multi-disciplinary teams within TS and JLR. It was a highlight to study the different cultures the team employs within these companies to solve internal and external challenges. This research has already led to new collaborations between WMG, JLR and TS for future projects in addition to fostering synergies such as the development of a wider project scope based on the framework of this research.

3.3 Project and Program Management Skills

This research required high level project management skills to coordinate various activities for the project. The project had multiple stakeholders and partners that were located in different parts of the country, with different timelines and priorities. The researcher had to deal with project management tasks as listed below:

1) Planning activities for project meetings and field for multiple partners at various locations at various locations in UK
2) Coordinating workshops and field trips involving multiple stakeholders from university and industries.

The researcher created a project management document which is annexed in the innovation report with Gantt charts, key contact notes from different meetings and field trips with the contact details of partners. As this project involves two different companies, the researcher had the opportunity of managing and leading changes of timelines and accommodating every individual's request within their scope whilst committing that the project timelines are maintained, and the goals are successfully achieved. The researcher has already gained 10 years of management experience in his previous assignment prior to this research. However, every project is different, and

the learning gained during this research helped the researcher gain significant skills in organisational skills, cultural management and human factors in an academic and an industrial setting. During this project, the researcher learned significantly in prioritizing multiple tasks and consistently maintain higher degree flexibility in a changing environment.

3.4 Teamwork Skills

As the project entered its final stages, a core project team was formed that consisted of a project manager from WMG, the researcher and the academic supervisor. It was essential to share the right information and match requirements from the industrial team members. The researcher gained good insights of how to address sensitive topics like non-delivery of data from partners and still being consistently persuasive. The researcher improved personal skills by following the project manager's planning and communication skills. The teamwork skills learned during this research has not only benefitted this current project and consortium but also supported in building long lasting relationships and networks beyond the project duration.

3.5 Leadership Skills

On several occasions, when the project partners were involved in other critical issues within their organisations, it was important for the researcher to initiate dialogues with the concerned parry despite their constraints of time. The researcher managed to lead initiatives such as organising joint telephone conferences and workshops with all partners and guarantee a smooth project management phase. The researcher has shown an extraordinary commitment to respond rationally to positive and negative feedbacks. The researcher has also supported in a role of MSc Supervisor to mentoring four MSc students in completing their dissertation. Out of the four MSc students, two of them graduated with distinctions. The researcher also completed 2 MSc modules related to leadership (Leading Performance and Leading Change) that has significantly helped to navigate environments that required leadership.

3.6 Oral and Written Communication Skills

This research has provided a strong platform to write research portfolios which are categorized as submissions. The researcher has also participated and submitted 10 MSc module assignments which were in average of 5000 words. The researcher has over seven years of experience in writing research grants in the previous tenure and that experience helped to explain complex terminologies in a simpler format for a non-academic target group. The researcher has also participated in three WMG Doctoral conferences and presented the research to different groups. The presentations at the WMG doctoral conferences also provided a platform to debate complex supply chain issues with industrial partners that were not involved within this research but are interested in joining the project in a larger experimental phase.

3.7 Technical Organisational Skills

This research required technical skills related to segmentation analysis. A variety of tools were used like referencing software, tableau and Excel to develop the relevant results. A maturity assessment tool from Crimson and Co was also used during this research project. The project planning was based from MS Excel.

3.8 Self-Application to new and Unusual Solutions

In this research, the researcher has gained valuable experience in identification of academic skills that can be transferred to an industrial context, such as the value chain innovation framework developed during this research from academia, is now proposed to teams within TS and JLR. The researcher also identified the value of academic theory that helps to identify the root causes of a given problem. The researcher has never designed or conducted a survey prior to this work and the research for the Enabler and Inhibitor analysis was analysed with the help of a survey designed explicitly for this research. This research also provided opportunities for the researcher to write different levels of reports such as a brief abstract to a conference to an elaborate portfolio submission.

3.9 Ability to Search Relevant Information Sources & Seek optimal solutions to complex problems.

The area of expertise was developed by activities such as:

1. Conducting literature reviews in the area of manufacturing strategy, productivity, value chain and supply chain.
2. Synthesis of data valid for this research from academic papers, innovation and industrial reports.
3. The ability to comprehend information that fits in this research context.

As this research is based on a mix-methodology, a qualitative analysis in a social context is open for a detail analysis because it is difficult to measure cultural constraints that are nurtured from a human perspective and perception. However, referring back to the manufacturing strategy portfolio submission, the capabilities of organisations with respect to performance, profit, cost and delivery can be measured and is measured in the research. Nevertheless, an optimal level in terms of performance indicators agreed by the companies involved, is less explicit in this work. The companies use their own maturity assessment tools to decide however, it was also identified that the companies' usage of this measurement again varies between customers, markets and even departments. Based on this conclusion, optimal solutions are difficult to achieve for problems in this exploratory context. Thus, solutions offered in this research are linked with social constraints derived from different cultures, despite its core engineering focus.

4 Doctoral Training Program and MSc Modules

The researcher during the course of this program attended the Doctoral Training Program offered by WMG leading to a “Post Graduate Certificate in Social Research”. The academic degree was awarded in September 2016 after successful completion of four written assessments. The Doctoral Program was not mandatory but was recommended by Dr. Janet Godsell in careful consideration of the researcher’s background which was primarily on Engineering. As a part of Eng-D program, the graduate school advised the researcher to enrol in six MSc modules which were considered to be appropriate for the research. The researcher successfully completed all the 10 modules including the DTC with a cumulative GPA of 66.5 % across all the subjects.

4.1 DTC Modules

The courses attended in the DTC are as follows:

1. Philosophy of Social Science Research (A Technology Development Perspective).
2. The Practice of Social research (The Relationship between Theory and Research Methods)
3. Qualitative Methods
4. Quantitative Methods
5. Research Methodology

4.2 MSc Modules

The Courses attended in the MSc modules are as follows:

1) Supply Chain
2) Logistics and Operations
3) Leading Change
4) Leading Performance
5) Innovation
6) Product Development and Design.

5 Conclusion

During this course of this program, the researcher has gained these skills as outlined in Figure 1.

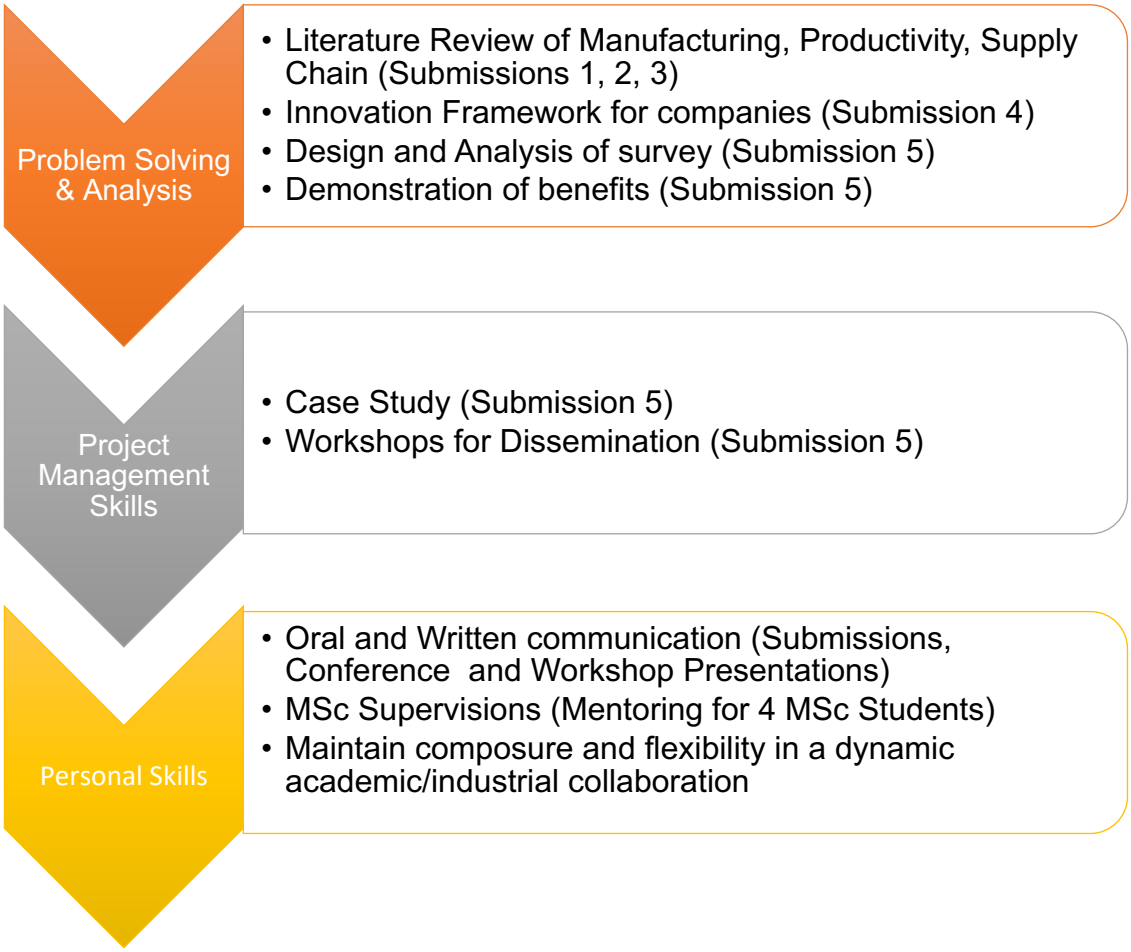

Figure 2 : Skill Summary