Big Star Assemblies, Inc.

A Case Study of
Securing Competitive Advantage Through
Supply Chain Management
And IT Collaboration

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Assignment 1—This is your introduction to the company positioning you as a newly hired VP of Supply Chain. Your mission is to collaborate with the management team of the company, perform a preliminary evaluation of process performance, take the lead in an improvement initiative, and develop a plan to achieve competitive advantage by adopting new technologies for the organization.

Assignment 2—With this assignment you will play the role of a member of Big Star's vendor evaluation team. You will assess the vendor's best practice IT and business solutions related to your process, and you will determine the fit of each vendor's best practices to your Value Propositions.

Assignment 3—On this assignment you will play the role of a team lead on Big Star's ERP-SCM implementation project. You will have to identify detailed requirements and guide your team through the decision making process during the design and build phase. Then you will be responsible for ensuring that testing is performed and that users under your functional purview are properly trained and ready for go live.

Assignment 4— This is a case focusing upon value attainment after the ERP-SCM go live. You will play the role of the supply chain VP working collaboratively with suppliers to use technology to solve on-time delivery problems by integrating IT systems with your suppliers and by improving supplier quality.

Assignment 5— This is an assignment for research students only. You will continue to play the role of VP by collaborating with a Product Manager and the Finance team to reduce inventory costs while ensuring that on time delivery meets customer requirements consistently.

Assignment 6—This is an assignment for research students only. You will continue to play the role of VP by collaborating with a Sales Manager to review and critique an analytical methodology seeking to improve the conversion rate of sales leads to actual sales orders.

Assignment 1

Situation Analysis

Jim Smith is the newly hired supply chain vice president at Big Star Assemblies, Inc. He has been brought on board by the CEO of the company to fix on-time delivery problems and quality problems that have been chronic pain point for Big Star customers. Big Star's dominant market share is now being threatened by the recent entry of a new, aggressive competitor that is a subsidiary of a Fortune 100 company.

Jim's mission is to assess the situation and to lead a "business transformation" initiative that results in the retention of Big Star's dominance in the marketplace. The CEO has assured Jim that he will have the support and resources necessary to make the required changes in the organization.

Company Background

Big Star Assemblies, Inc. is a 60 year old producer of widgets for an OEM industry. Big Star sells exclusively through a network of 50 value added resellers (manufacturer's reps and distributors) who in turn sell directly to OEMs. Current annual sales are $12 Mil.

An analysis of sales performance (Figure #1 and #2) show that Big Star has five key customers and 45 smaller customers. Over the last five years Big Star has seen a steady decline in sales and gross margin. Market research studies show tremendous dis-satisfaction by all customers with on-time delivery performance and quality failures of the product in the field.

Big Star's advantage in the market is through the companies willingness to customize products to fit the customer's exact requirements using a make to order (MTO) operations strategy. The product line offering consists of over 10,000 finished goods materials across 48 product families. All products carry similar Bills of Material (BOMs) consisting of four raw material components—Component A, Component B, Component C and Component D. Big Star's value add is in assembling these materials in a unique way. Product customization is achieved through variations in routing step instructions.

Jim's Approach

Jim decides that a twofold strategy is required to successfully complete his mission. First, he must ensure that internal processes are under control by establishing key metrics along with process improvements and controls using a DMAIC approach. Secondly, he wants to compare Big Star's operation with best industry practices and then use the Six Sigma approach to drive the organization to the adoption of these practices.

To gain a perspective on these two areas of pursuit, Jim makes appointments to interview several of his senior management colleagues including: Sheila Jackson (Quality Manager), Bill Streamwood (Operations Manager), Joe Taylor (IT Manager) and Katherine Graves (Finance VP) .

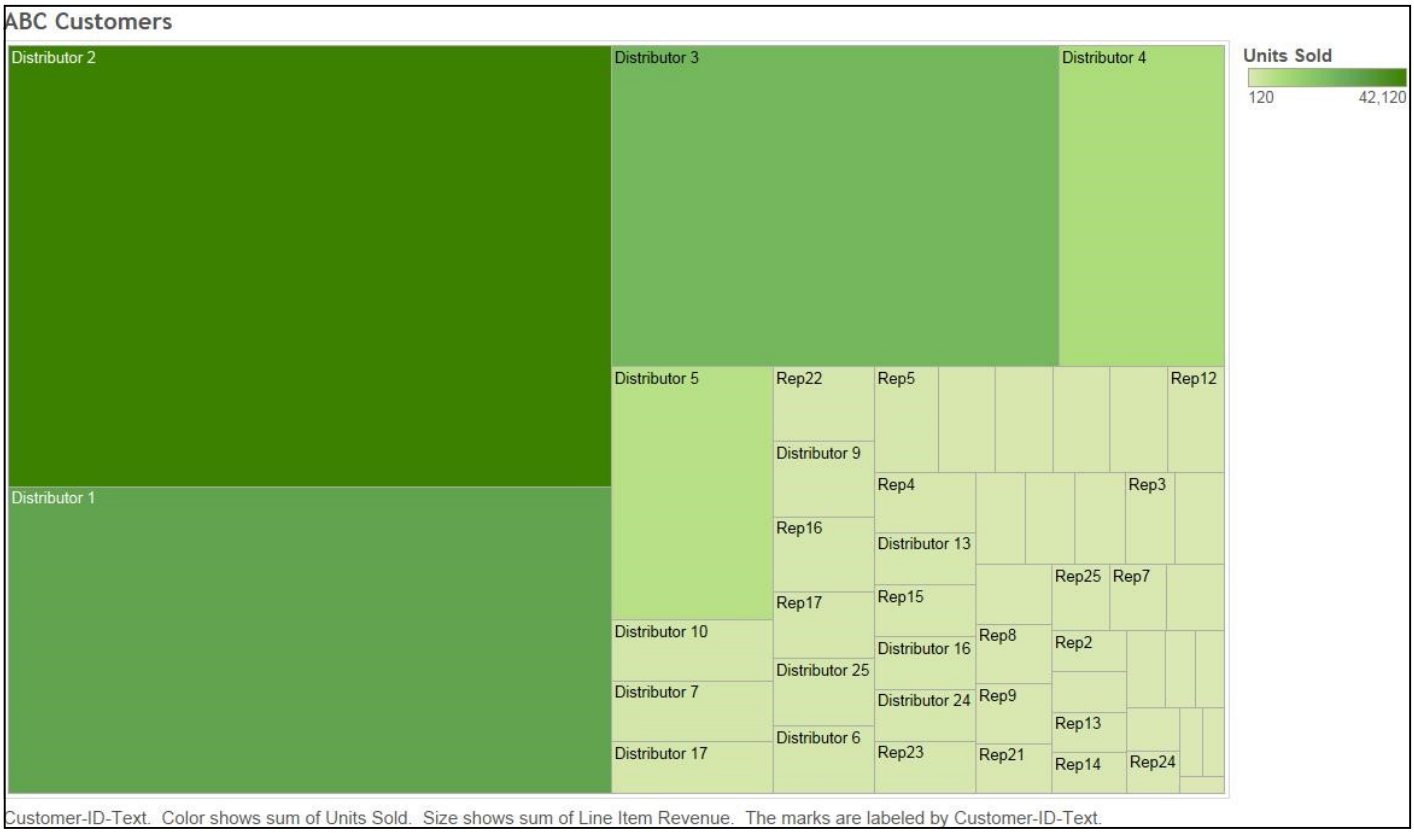


Figure 1-ABC Analysis of Big Star's Sales by Customer 2011-2015

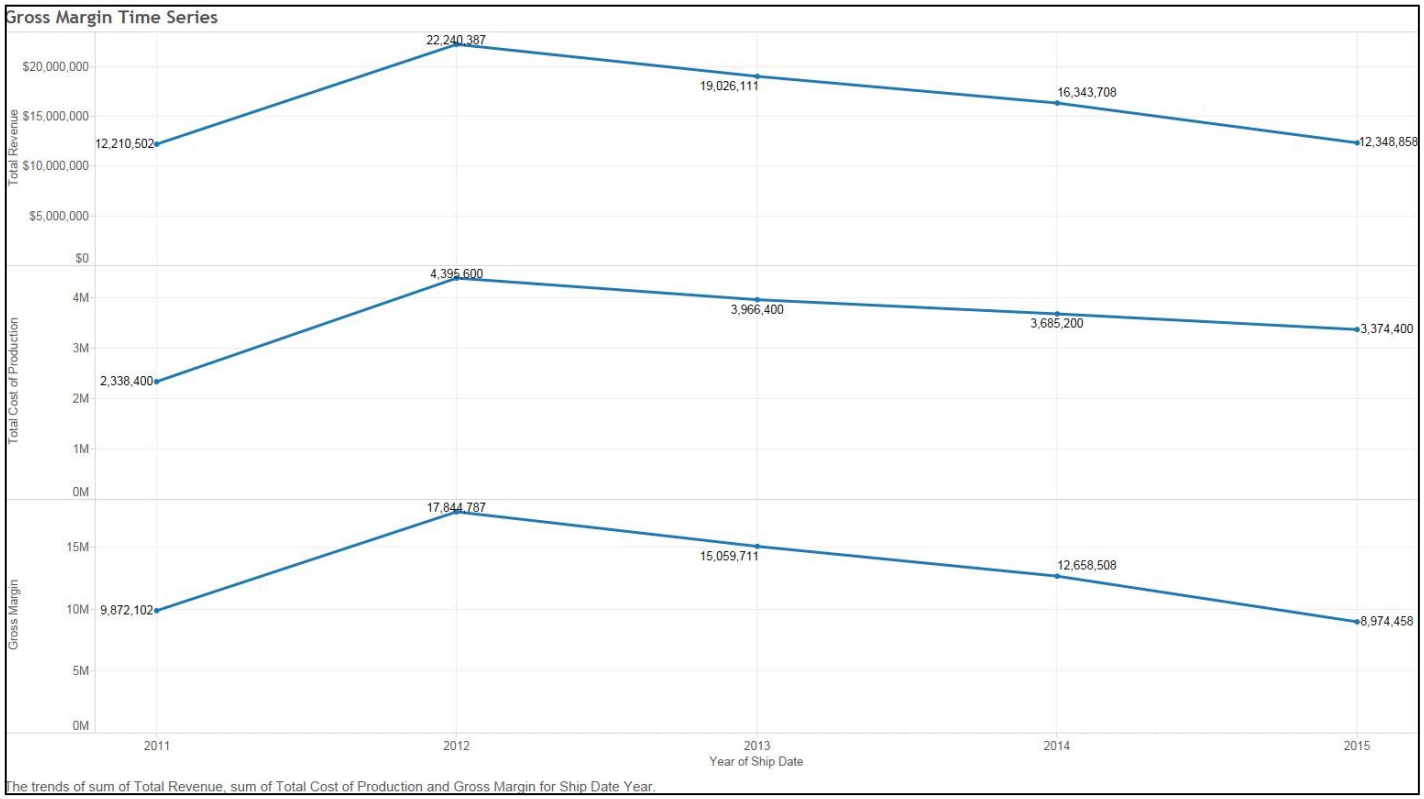


Figure 2- Big Star's Sales

Meeting with the Quality Manager

Jim meets with Sheila. She provides him with a histogram of On-Time-Delivery performance and well as reason codes for late shipments. Refer to Figures 3 and 4 below.

Sheila confirms that On-Time-Delivery performance has been very poor. Delivery was late for over 50% of the deliveries to the top 5 customers. Sheila believes that the sales team is consistently quoting lead times to customers that can not be achieved. She also indicates that the company refuses to carry adequate raw material inventory to handle surges in demand. She believes that the company has a bloated finished goods inventory of the wrong SKUs to meet customer needs. Without accurate reporting of finished goods inventory, the operations manager typically blames the sales team for committing to unachievable ship dates as well as for vendors for being late in their deliveries. She also states that in many cases the reported root cause of late deliveries is "poor workmanship" in the manufacturing work centers which is not being addressed.

Jim and Sheila sketch out the process map for Big Star's internal operations as shown in Figure 5.

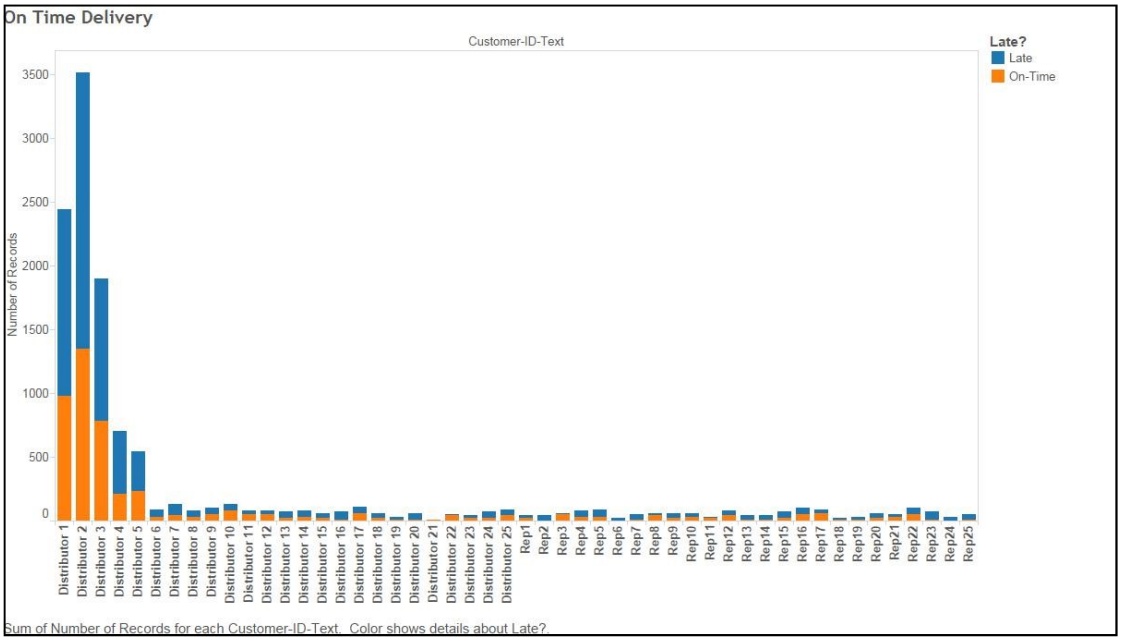


Figure 3- On Time Delivery Performance by Customer 2011-2015

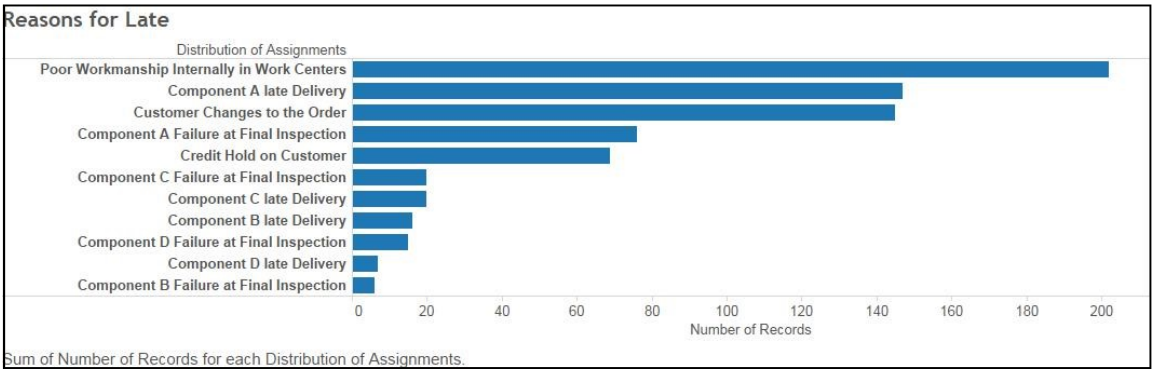


Figure 4– Assigned Reason Codes for Late Deliveries

Process Map of Big Star Assemblies Legacy System

Supply Chain Manager's Perspective

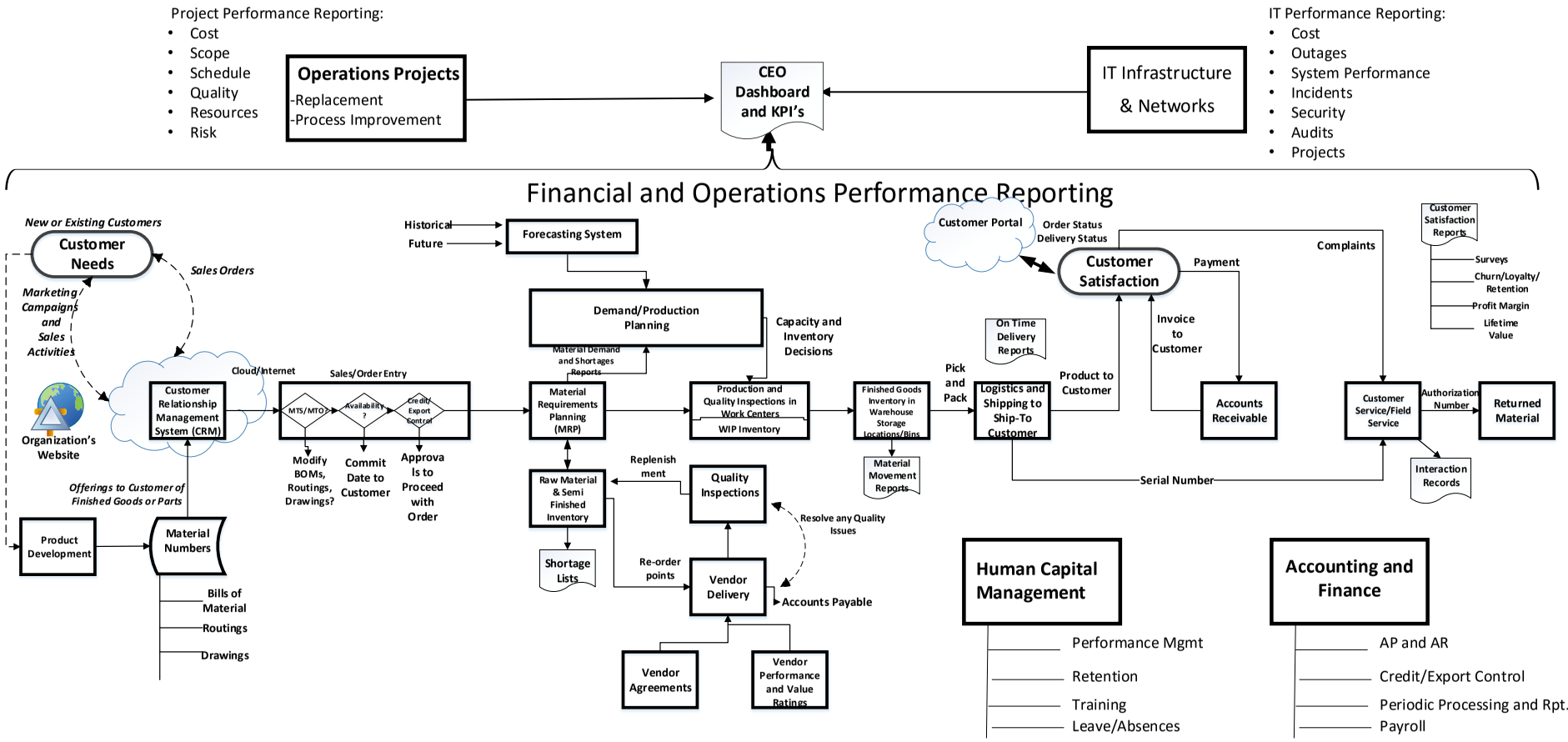


Figure 5-High Level Process Map Big Star's Internal Operation

Meeting with the Operations Manager

Jim meets with Bill Streamwood, the Operations Manager who is responsible for procurement, manufacturing, inventory and warehouse management, shipping and delivery.

Bill provides Jim with the chart shown in Figure 6 showing total spend by raw materials and by vendor. Bill admits that the vendors have had some on time delivery problems and some quality problems. But his focus has been on working with the people in the work centers and getting the goods out the door. So, he really has not had the time to work with vendor programs.

Bill and Jim sketch out a supply chain process flow as shown in Figure 7. Jim raises some of the questions shown in Figure 7 and Bill really can not provide an answer. Bill becomes defensive and emphasizes that his primary job is to work with the people in the work centers. Bill further indicates that the company fired the procurement manager last year and the responsibility for purchasing was dumped on him. The procurement manager reported to the Finance VP and not him. The transition was never properly managed.

Bill also mentioned that the currently legacy system is incapable of providing an accurate report of finished goods inventory on hand.

Component	Supplier
A	Alpha Company
B	Beta Company
C	Gamma Company
D	Delta Company

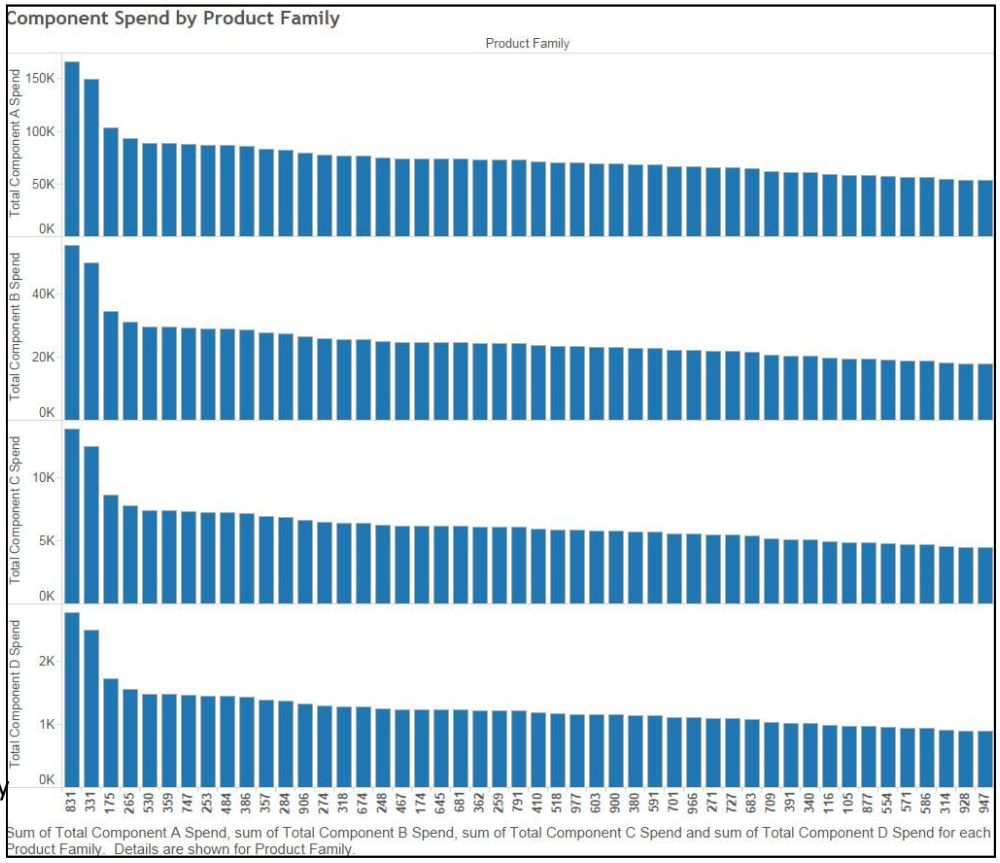
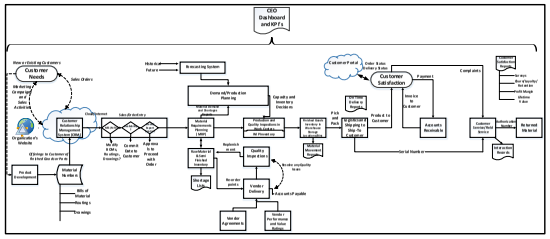


Figure 6—Raw Material Spend by Component and Vendor

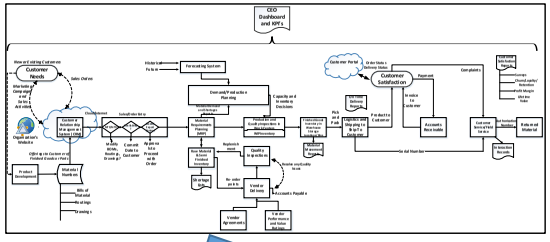
Common SCM Technology Questions:

- How to secure competitive advantage vis-à-vis competitors and mitigate competitive challenges
- How to supply greater value to customer and better serve the customer
- How to secure greater value from suppliers and logistics carriers
- How to avoid/mitigate risks of business disruption
- How to become more efficient, easier to do business with
- How to provide adequate internal performance reporting and analytical capabilities
- How to avoid outages and ensure security
- How to ensure data governance
- How can we integrate facilities and capabilities
- How can we leverage global capabilities

Big Star's Customer's Customers



Big Star's Operation

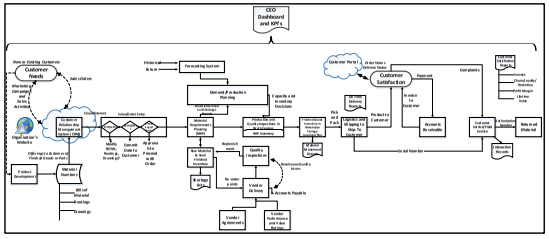


Big Star's Customers

Manufacturer's Reps

Distributors

Big Star's Tier 1+ Suppliers



Expanding the Flow with a More Strategic Perspective

Meeting with the IT Manager

Jim meets with Joe Taylor, the IT manager. Joe provides Jim with a landscape view of the company's IT architecture (as shown below in Figure 8). Joe expresses confidence in the company's network performance, security and disaster recovery. On the other hand, Joe indicates concern over the company's current IT applications. The current system is using an old Microsoft platform that is a patchwork of independent applications, and the master data governance has been poor. Joe gives an example where the same customer may have up to five different spellings, have 20 different "sold to addresses" and have 30 different "ship to addresses". In Joe's view finding anything in the current system takes a very long time.

Jim provides Joe with the list of 20 key supply chain metrics that he requires (see Figure 9). Joe gives Jim a raw data extract of the key transactions captured in the systems since 2011. Joe also gives Jim a map showing the Structured Query Language (SQL) linkages between the database tables that is used for report development. See Figure 10.

Joe mentions to Jim that the company really needs an integrated ERP system and a massive data cleanup effort.

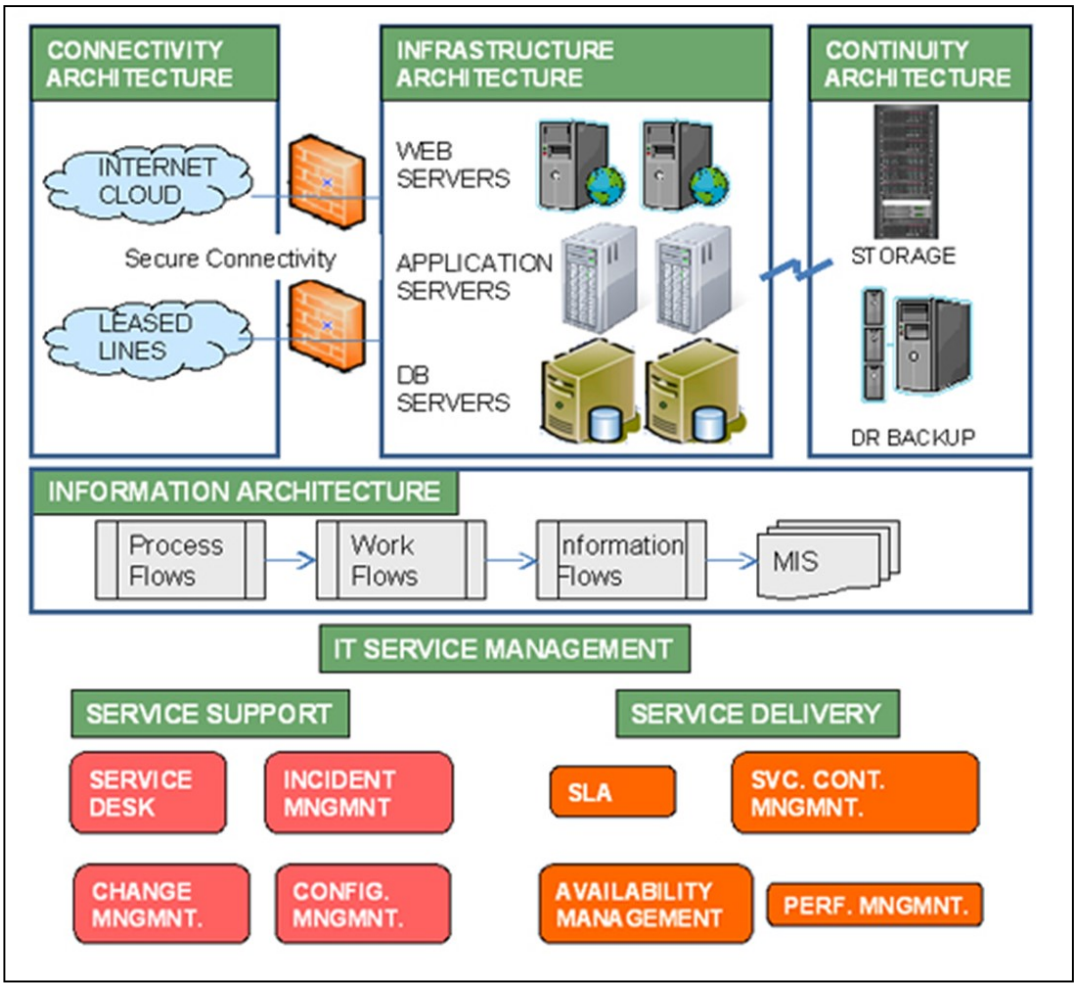
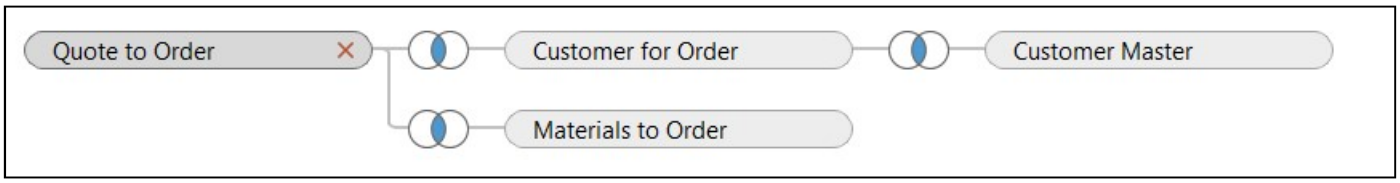


Figure 8 —Big Star's IT Landscape

	12 Key Metrics	Current	Q1	Q2	Q3	Q4	YTD Percentage Improvement
1	Inventory Investment						
2	Profit/Loss						
3	Inventory Efficiency (Turns)						
4	On-Time Supplier Delivery						
5	Forecast Accuracy						
6	Lead Time						
7	Unplanned Orders						
8	Schedule Changes						
9	Overdue Backlogs						
10	Data Accuracy						
11	Material Availability						
12	Excess Inventory						
	Additional Metrics						
13	Customer Service Target						
14	NOPAT						
15	Asset Efficiency						
16	Fixed Asset Efficiency						
17	Receivables Efficiency						
18	Profit Margin						
19	ROA						
20	GMROI						

Figure 9 —Jim's List of 20 Key Supply Chain Metrics and Tracking



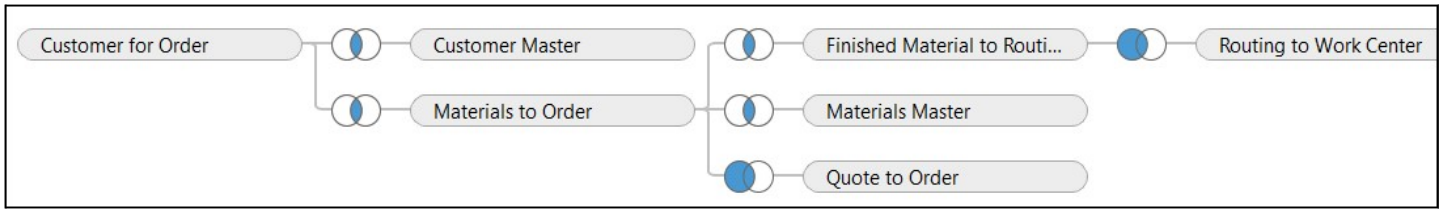


Figure 10 —Example of Linking Data Tables from Big Star's IT System Using Tableau Software

Meeting with the Finance Manager

Jim meets with Katherine Graves, VP of Finance to discuss inventory.

In preparation for the meeting Jim has performed his own time series analysis of the demand for raw materials and the inventory levels as shown in Figure 11.

During the meeting Jim asks Katherine how the raw material inventory levels get set. Katherine indicates that purchasing sets up the agreements with vendors and that she would only get involved if the inventory turnover went too low. She did express concern that the high inventory volume for component D made little sense to her. But traditionally the company has always maintained a high inventory for that component.

Katherine calculated inventory turns for the four raw materials as:

⇒ Component A=6.6

⇒ Component B=235.1

⇒ Component C=2.3

⇒ Component D=0.2

Katherine confirmed that the company needs an ERP system to obtain visibility to finished goods inventory. She mentioned that the Finance team believes that finished goods inventory is often excessive for a make to order (MTO) company, and Big Star is carrying obsolete products that customers no longer order. She also indicated the labor cost for manual entries and workarounds in accounting would easily justify the installation of a new system.

Jim's Approach and Your Assignment

Jim decides that it will be important to organize a process improvement team consisting of key people from various functions. Jim further decides to leverage the DMAIC project structure along with its various associated tools. Jim believes that the current IT system has some gaps that will be identified by using this approach.

In order to prepare for his first meeting with the team, Jim uses the Fishbone diagram template and the Idea Map template within Minitab's Quality Companion application.

We assume that you will play the role of Jim. Your assignment is to go into Minitab Quality Companion and:

1. Set up a DMAIC/DFSS project as shown in Figures 12 and 13 using Minitab's Quality Companion software.
2. Populate the Idea Map and Fishbone diagram templates using the information provided in this case. You may wish to read ahead at assignment #4 and review Figures 28-32 to gain a sense of Big Star's current process capability.
3. Read through the Quality Companion documentation and be prepared to show your work and discuss at next week's meeting of this class.
4. Develop an Agenda for the meeting that covers the Seven Principles of Supply Chain Management as topics for discussion.

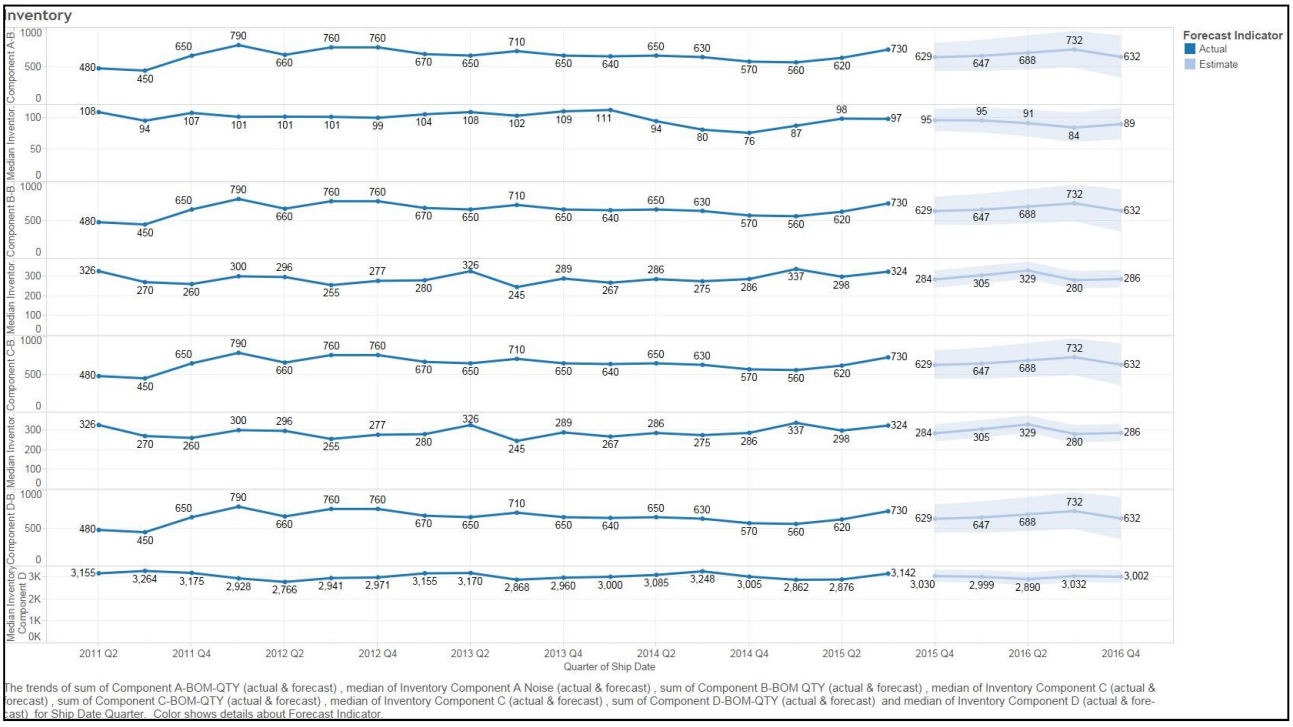


Figure 11 — Monthly Raw Material Demand and Inventory

Figure 12 — Fishbone Diagram Template in Minitab Quality Companion

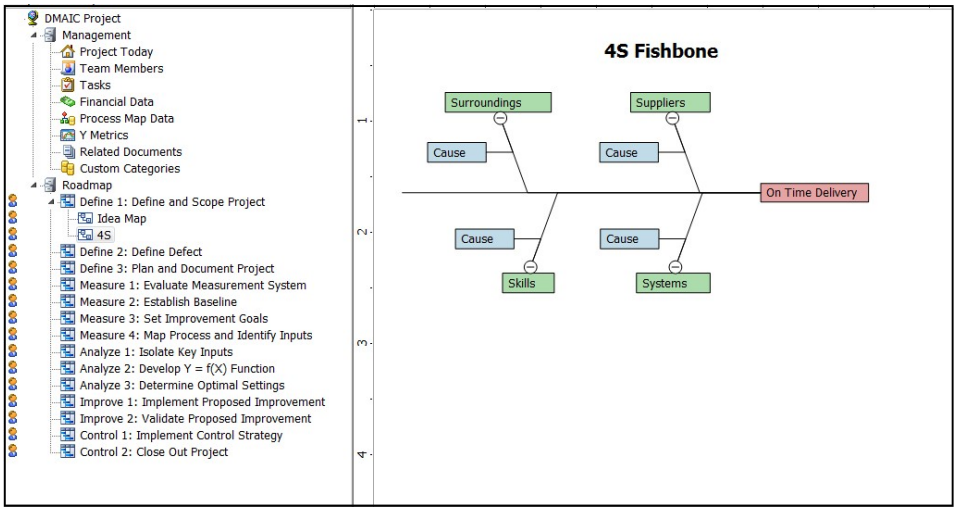
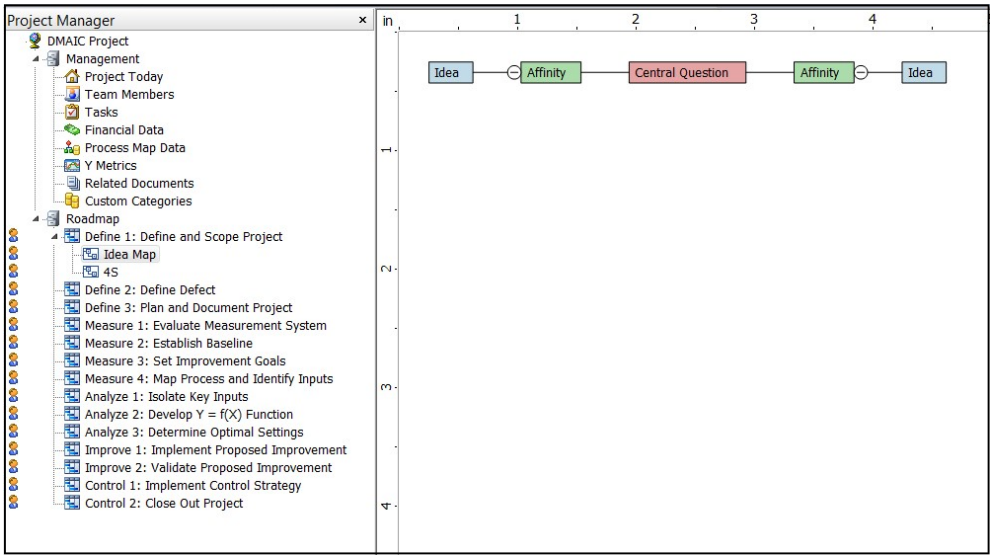


Figure 13 — Idea Map Template in Minitab Quality Companion



Assignment 2

Value Propositions and the Discovery Phase

We now move forward in time and assume that Jim's efforts have paid off. He has organized a process improvement team (See Figure 14 below) with responsible and accountable process owners. This team has used the DMAIC process to ensure basic process capabilities and controls are in place. The team has observed, however, that the overall functionality and reporting of the current IT system is inadequate to keep Big Star to competitive. Also the team now realizes that Big Star is operating in silos without integration between departments, with suppliers and with customers.

It is also clear to the team that the company is in dire need of better business intelligence to guide decision making.

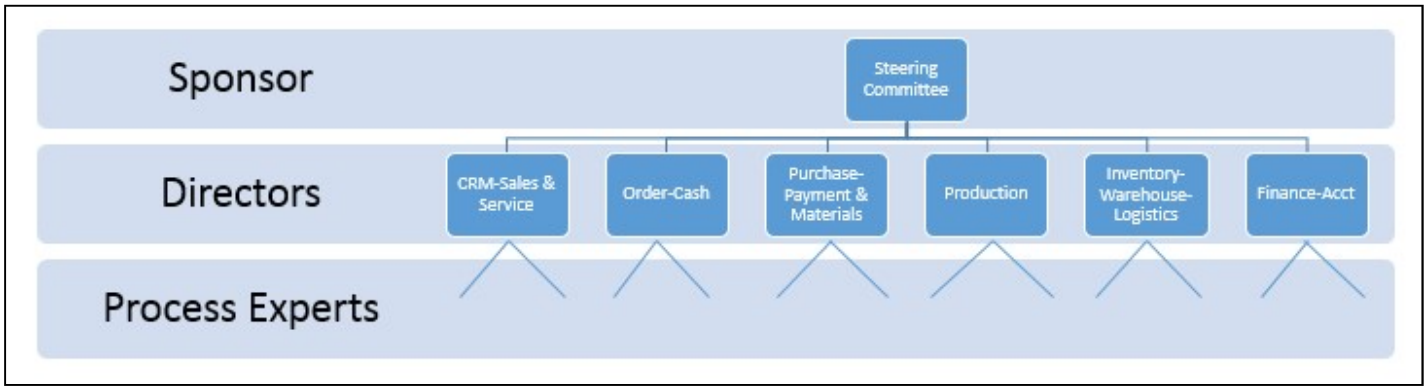


Figure 14– The Structure of Big Star's Improvement Team

Jim works with his team to charter a project with the objective of reviewing and evaluating alternative vendor solutions that could replace Big Star's current IT system. Each of the vendors come on-site to Big Star, present and demonstrate their various "best practice" industry solutions that are appropriate for Big Star and answer questions. The Big Star team scores each solution for value. An example of a suite of best practice solutions is shown in Figure 15 below.

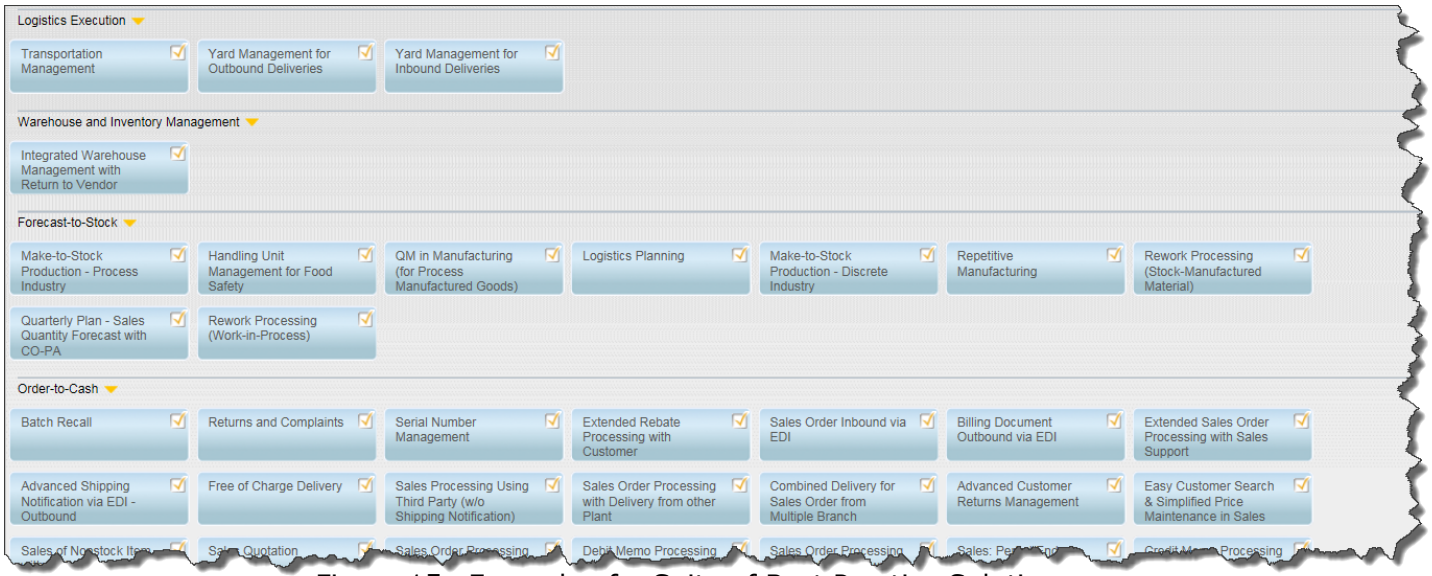


Figure 15– Example of a Suite of Best Practice Solutions

Each Big Star team member performs an evaluation and provides a score for each process under his/her purview by comparing each vendor's best practice functionality and reporting capability with Big Star's targeted Value Propositions. As an example, Figure 16 and Figure 17 illustrate the scope of process steps that would be contained for the process "Purchasing of Consumable Goods or Services". Figure 18 illustrates how that process would support a value proposition.

Jim, the SCM VP is very interested in available tools to optimize the supply chain performance, value and risk. Figure 21 on page 17 lists the suite of available functions that could help satisfy that requirement at Big Star. Jim believes that designing an optimized and integrated supply chain model would bring significant value to the company.

Figure 16-Purpose, Benefits and Key Process Steps
of Best Practice *"Purchasing of Consumable Goods or Services"*

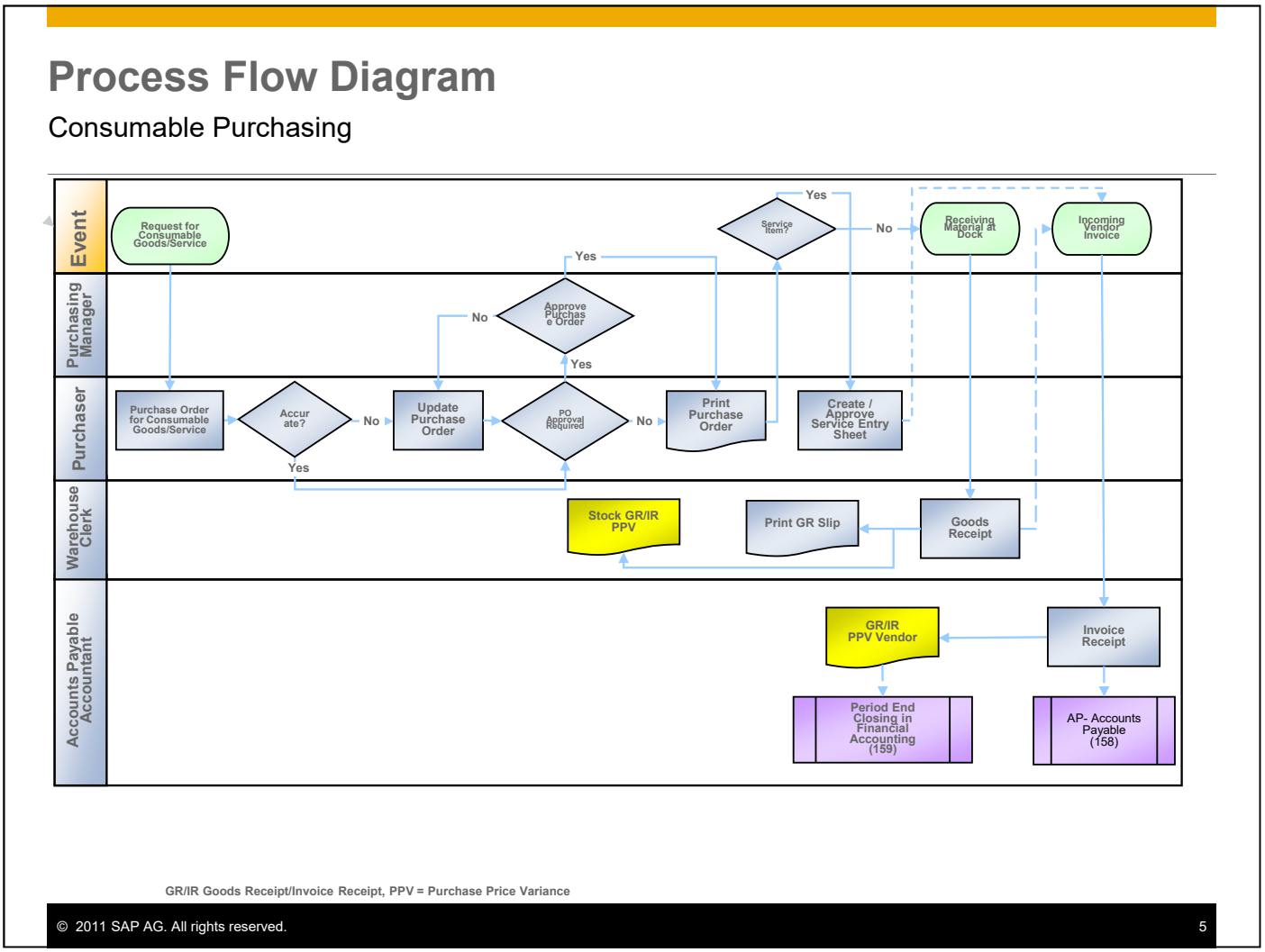


Figure 17-Process Steps and Roles for *"Purchasing of Consumable Goods or Services"*

			Costs					Probability Of Success			
No.	Value Proposition	Best Practice Solution(S)	$ Value of Benefit at Stake	Acquisition	Implementation	Implementation Duration	Ongoing Cost (five years)	Technical Success	Technical Success Log	Adoption	Adoption Log
1	Better Control over Maverick Spending	SAP Purchasing of Consumable Goods and Services	200000.0	10000.00	5000.00	12 months	3000.00	0.95	2.79	0.99	2.97
		Summary Level	200000.00	10000.00	5000.00		3000.00	0.95		0.99	
		Estimated ROI	1111.11%								

Figure 18-Form Showing Linkage to Value Proposition with Best Practice

Your Assignment

Assume that you are part of Big Star's vendor evaluation team. Perform the following:

- Choose a business process, and then review the relevant documentation of SAP best practices processes related to that process (or use another vendor's best practices).
- Using the "Seven Principles of Supply Chain Management" as your benchmark (or any others), identify five potential value propositions for the selected process, and populate a spreadsheet with the information requested in the form shown in Figure 18 for all five propositions. Calculate Return on Investment.
- Be prepared to discuss your results with the class.
- How could incorporation of the Risk Exposure Index (Ford Example) be described as a value proposition and as a best practice? How would you address this as a Supply chain VP at Big star? Investigate how supply network planning functionality (or any other best practice of your choice) could help Big Star and write a one-two page synopsis.

  Watch Ford Motor —Risk Exposure Index –David Simchi-Levin interview
  http://www.sctvchannel.com/webinars/Videocast_Ford.php?submissionGuid=1ba58393-6411-4d48-8f86-cb8a829b9a96

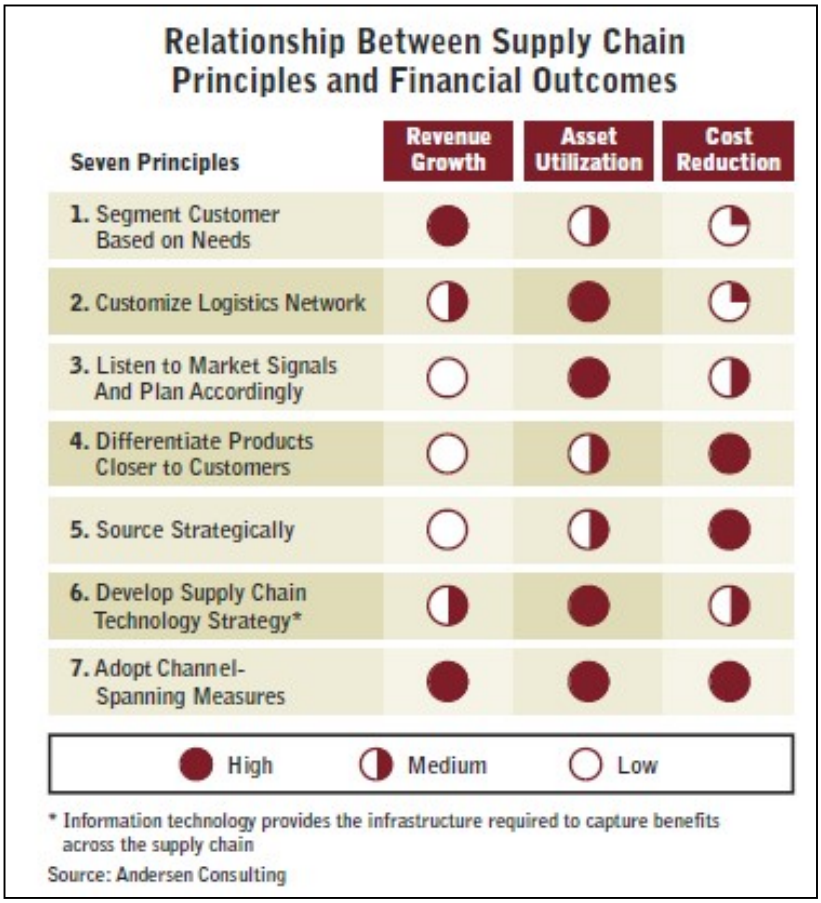


Figure 19-The "Seven Guiding Principles" that Jim Uses for Developing ERP Value Propositions

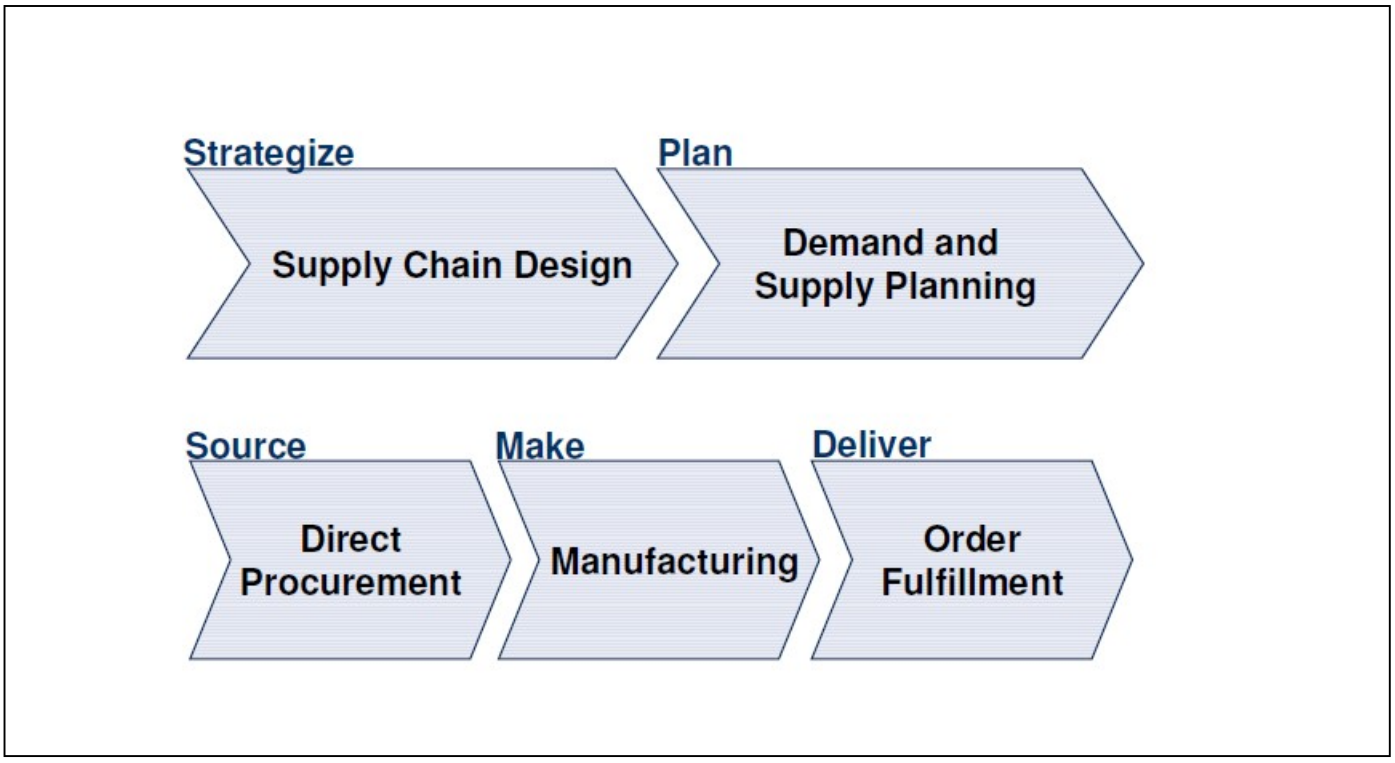


Figure 20-Key Elements of Jim's Integrated Supply Chain Model

Demand & Supply Planning	Demand Planning & Forecasting	Safety Stock Planning	Supply Network Planning	Distribution Planning	Service Parts Planning
Procurement	Strategic Sourcing		Purchase Order Processing		Invoicing
Manufacturing	Production Planning & Detailed Scheduling		Manufacturing Visibility & Execution & Collaboration		MRP-Based Detailed Scheduling
Warehousing	Inbound Processing & Receipt Confirmation	Outbound Processing	Cross Docking	Warehousing & Storage	Physical Inventory
Order Fulfillment	Sales Order Processing		Billing		Service Parts Order Fulfillment
Transportation	Freight Management	Planning & Dispatching	Rating & Billing & Settlement	Driver & Asset Management	Network Collaboration
Real World Awareness	Supply Chain Event Management			Auto ID/RFID and Sensor Integration	
Supply Chain Visibility	Strategic Supply Chain Design	Supply Chain Analytics		Supply Chain Risk Management	Sales & Operations Planning
Supply Network Collaboration	Supplier Collaboration		Customer Collaboration		Outsourced Manufacturing
Supply Chain Management with Duet™	Demand Planning in MS Excel				

Figure: SAP® Supply Chain Management Solution Map

Figure 21-A Suite of SCM Solutions Available to Integrate and Optimize at Big Star

Assignment 3

Participating in the ERP Implementation

We now assume that all of the functional groups within Big Star have identified, quantified and justified their value propositions. We further assume that the team has selected an ERP vendor that proposes to deliver the highest value by meeting Big Star's process requirements and satisfying the targeted value propositions. At this point Big Star works with the selected vendor to charter and execute an ERP implementation.

Figure 22 below illustrates the phases of a typical project life cycle that uses milestone Quality Gates with phase exit criteria. A project manager is assigned, and each function within Big Star assigns team members as resources to represent their function by making decisions and producing project deliverables.

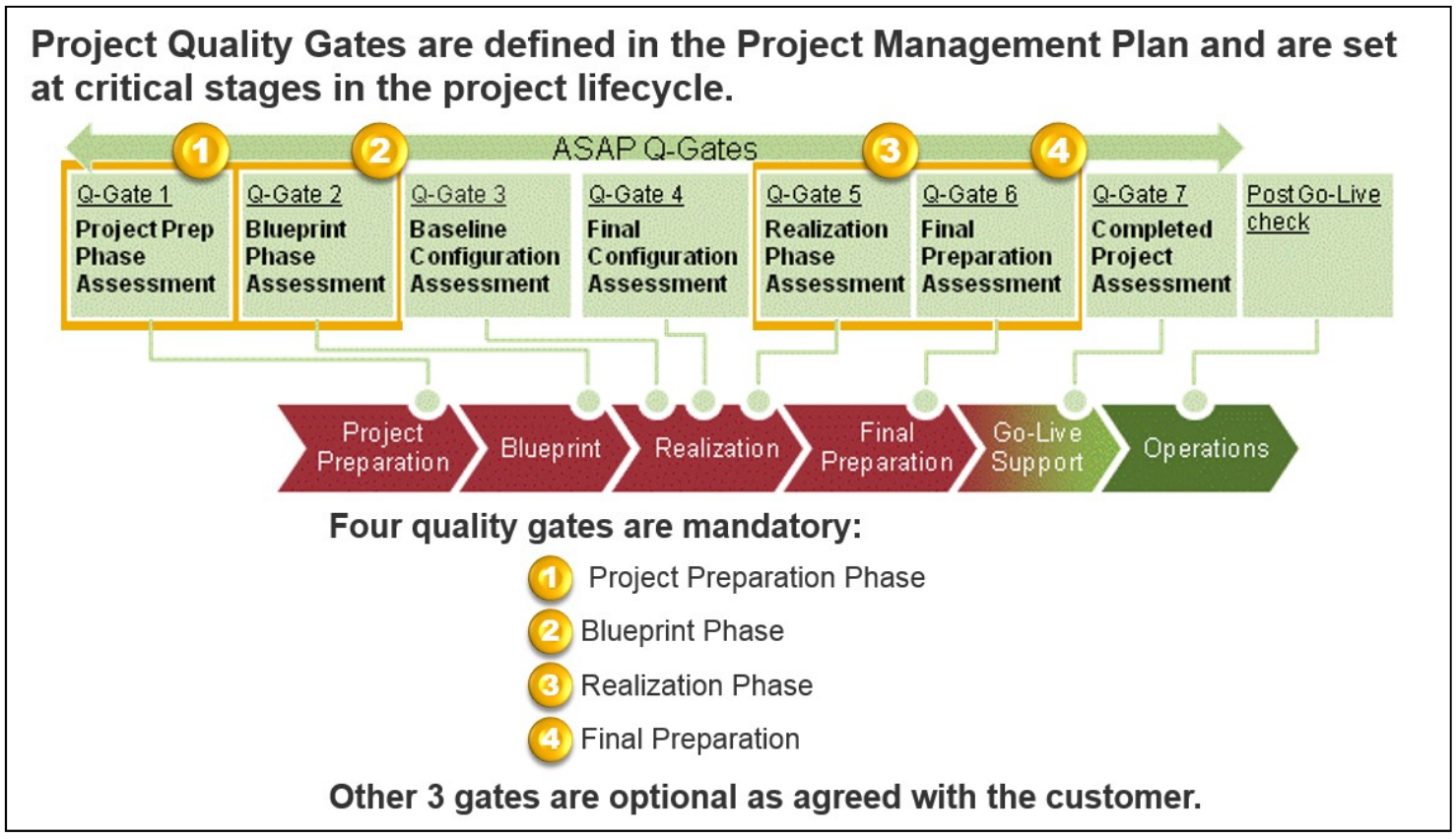


Figure 22– ERP Project Life Cycle

One of the most difficult aspects of managing an ERP-CRM implementation is controlling the scope of the project. A phenomenon called "scope creep" has destroyed many an ERP-CRM project, and ERP-CRM managers have struggled controlling project scope for years. Increasingly organizations are adopting iterative development methodologies in an attempt to identify and prioritize requirements as early as possible in the project. Figures 23 through 25 below and on the following page illustrate the Agile iterative approach to ERP implementation management as an attempt to address this need.

ERP-CRM projects are large scale endeavors that might best be called "business transformation initiatives" Technology and organizational change management are used to fulfill the value propositions that make the sponsoring organization more competitive.

Typical streams of work on these projects include:

- Business process configuration
- Data cleanup and harmonization across facilities
- Security
- Report development and business intelligence enablement
- Technical infrastructure

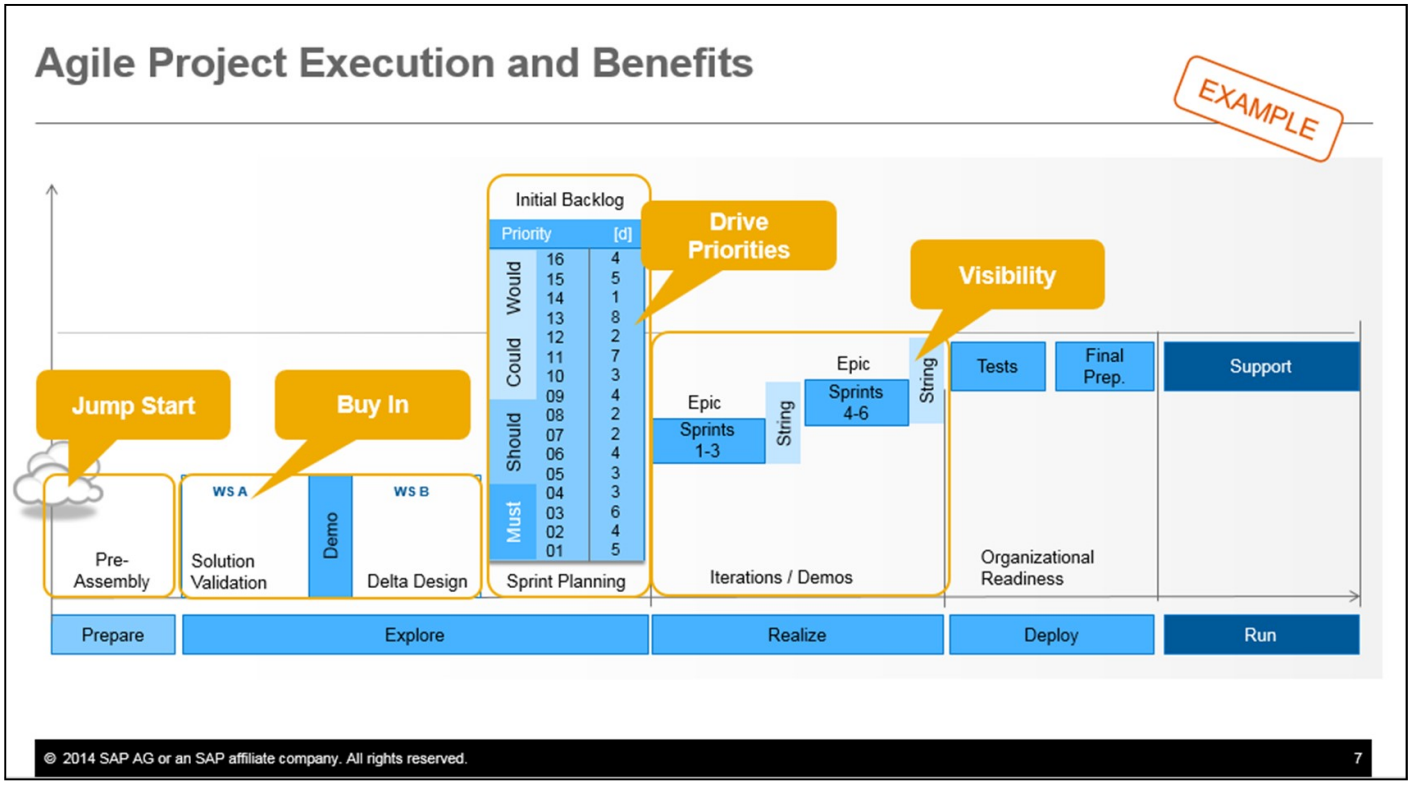


Figure 23-Agile Methodology for ERP and CRM

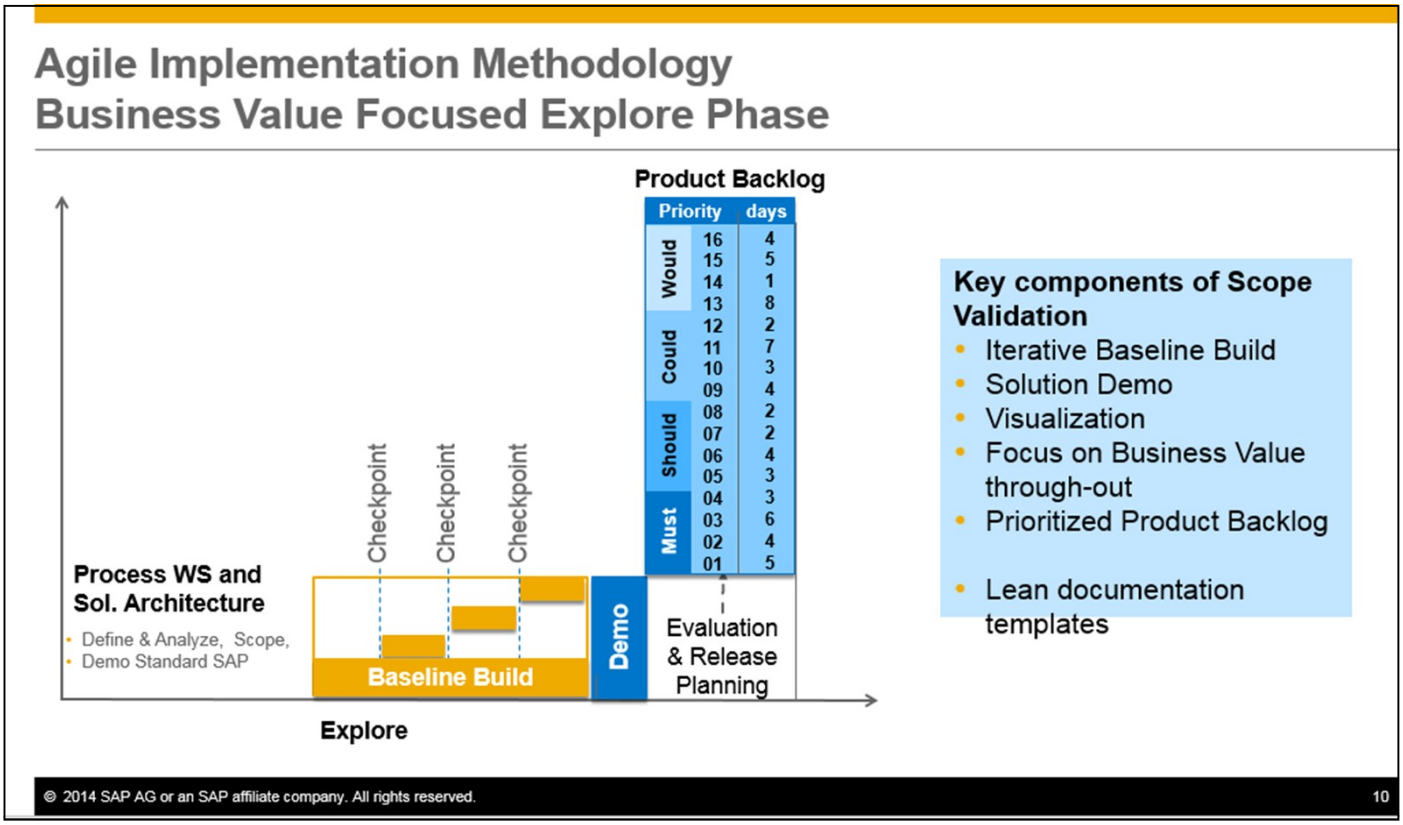


Figure 24—Agile Scope Identification Approach for ERP

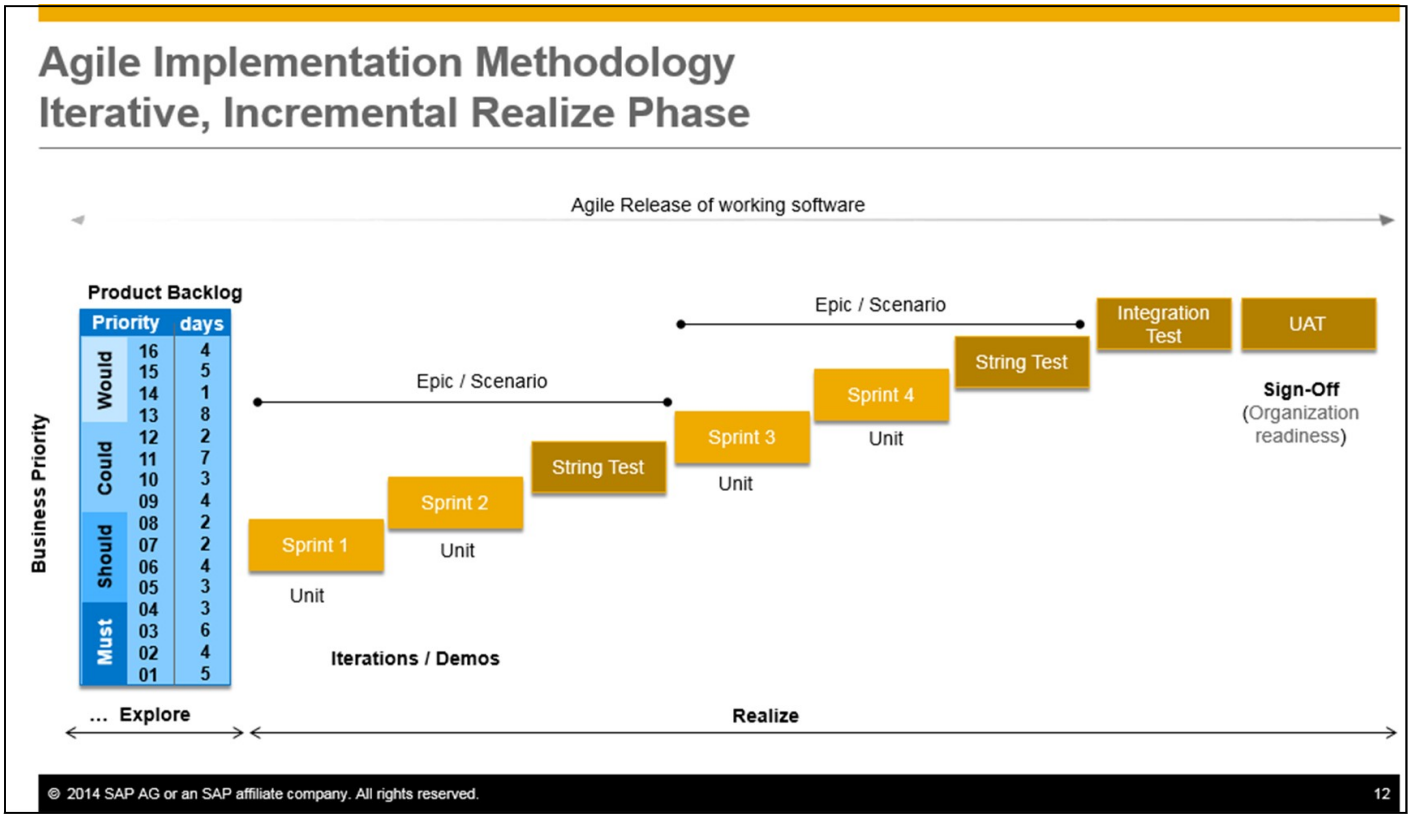


Figure 25—Agile Build and Testing Phases for ERP

In addition to implementing the technology, the project team must also work with the users to attain acceptance and adoption of the new tools and process procedures. The scope of this effort includes procedure writing, user training and organizational change management.

ERP and CRM projects often include conflict. Resistance to change by team members, users, functional managers and senior managers is a frequent occurrence that the project manager must work through.

Figure 26 and Figure 27 provide an illustration of the scope of organizational change management activities that must be a part of an ERP implementation.

Your Assignment

1. Develop a prioritized list of the selected best practice processes under your purview and label them in the categories as Must, Should, Could and Would. Describe how this prioritization could be helpful to an implementation.
2. Describe the likely organizational change management challenges that the Big Star ERP-CRM project team would likely encounter. What methods and tools exist to help overcome the organizational change management challenges?
3. Identify best practices functions that would enable Big Star to operate leaner internally and more collaboratively and in a more integrated fashion with your suppliers and customers.

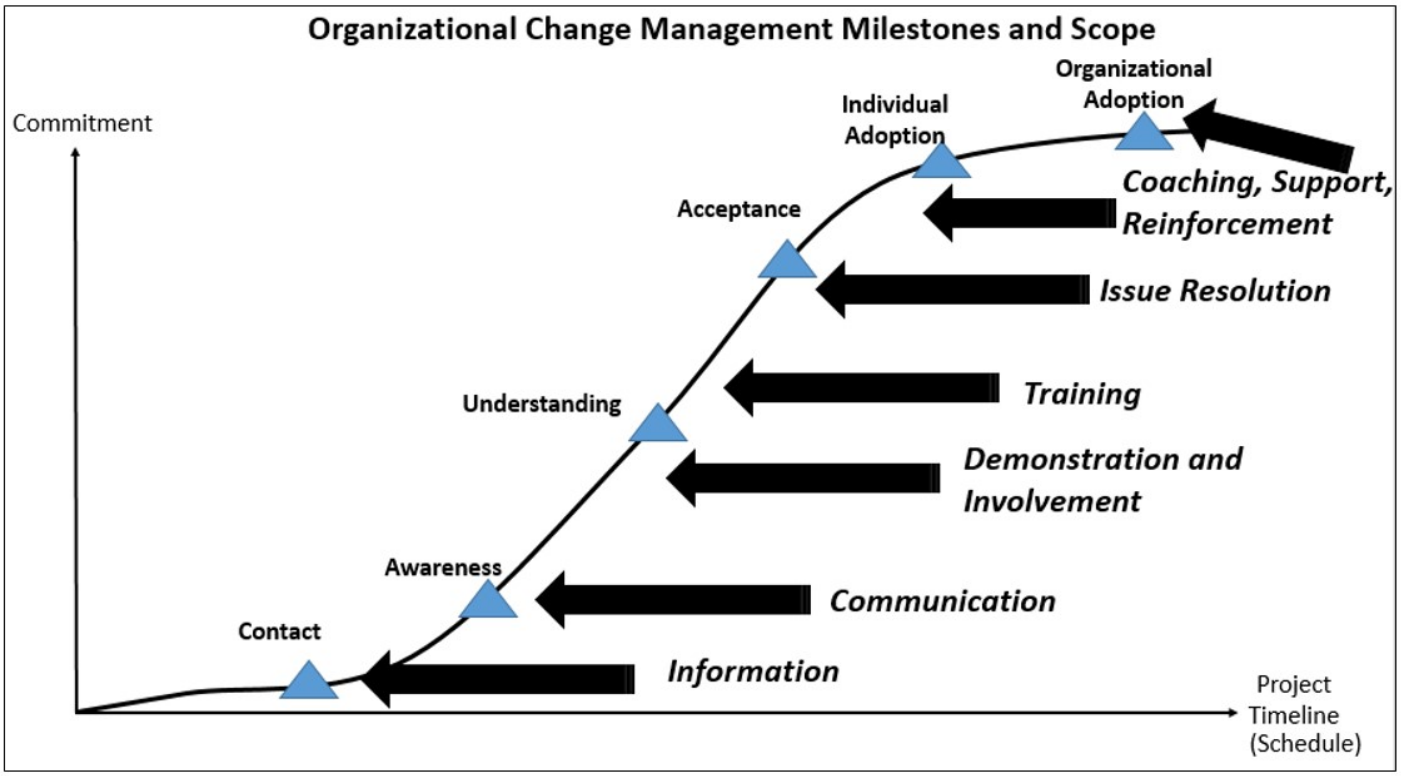


Figure 26—Example of an Organizational Change Management Milestones

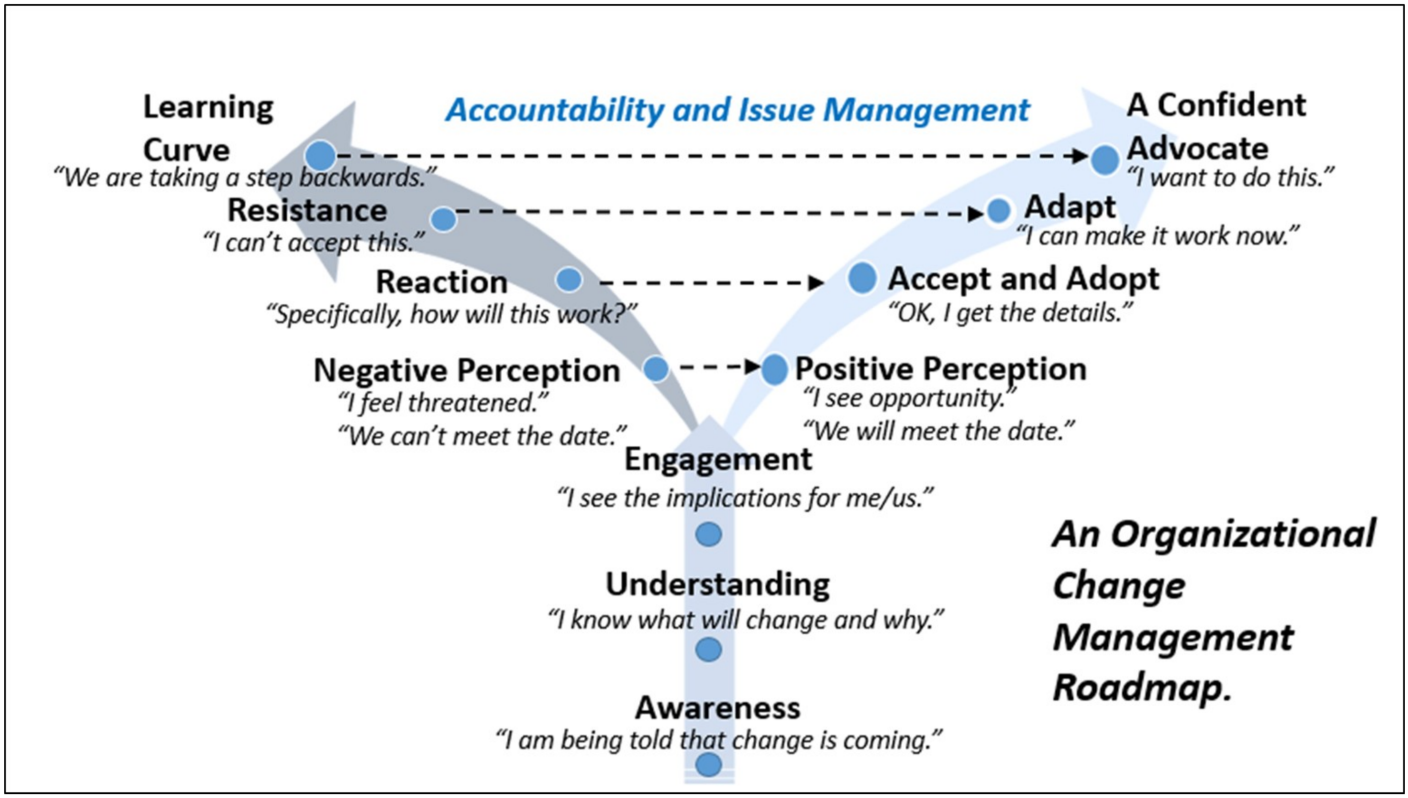


Figure 27—Example of an Organizational Change Management Roadmap for an ERP Project

Assignment 4

Engaging Big Star's Suppliers

Now with the new ERP-SCM system live, Jim decides to engage Big Star's suppliers in order to realize the targeted value propositions of the implementation.

Jim begins by reviewing the facts. He models Big Star's process capability as illustrated in Figures 28 and 29 on the following page. Jim uses the data from the system to model Big Star's throughput time (in days) for customer order fulfillment as shown in Figure 28. His analysis shows that the Lognormal distribution fits nicely as a predictive model.

Going further with his model, Jim determines that Big Star's current process is only capable of producing on-time delivery about 38% of the time which is a severe problem. Refer to Figure 29.

Jim then reviews the pareto chart of the causes of late deliveries (Figure 30) as well as the impacts from these causes (Figure 31) as he prepares for his meetings with his suppliers.

Also, as part of his preparation Jim develops the flow diagram shown in Figure 32. Jim also builds a Value Stream Map (Figure 33) to support his DMAIC project. The value stream map (available as a tool within Minitab Quality Companion) can be used to identify waste and opportunities in material movements with:

- Suppliers and incoming logistics for raw materials
- Internal Operations
- Outgoing logistics to intermediary customers and to the final customer for finished goods

Your Assignment

1) Play the role of Jim. Develop an agenda for your meeting with Big Star's suppliers.
2) Identify the specific systemic improvements and value added changes that Jim should propose to the suppliers. Describe how the new ERP-CRM system would support these improvements.
3) Describe how data mining techniques could be used to uncover hidden opportunities for improvement.

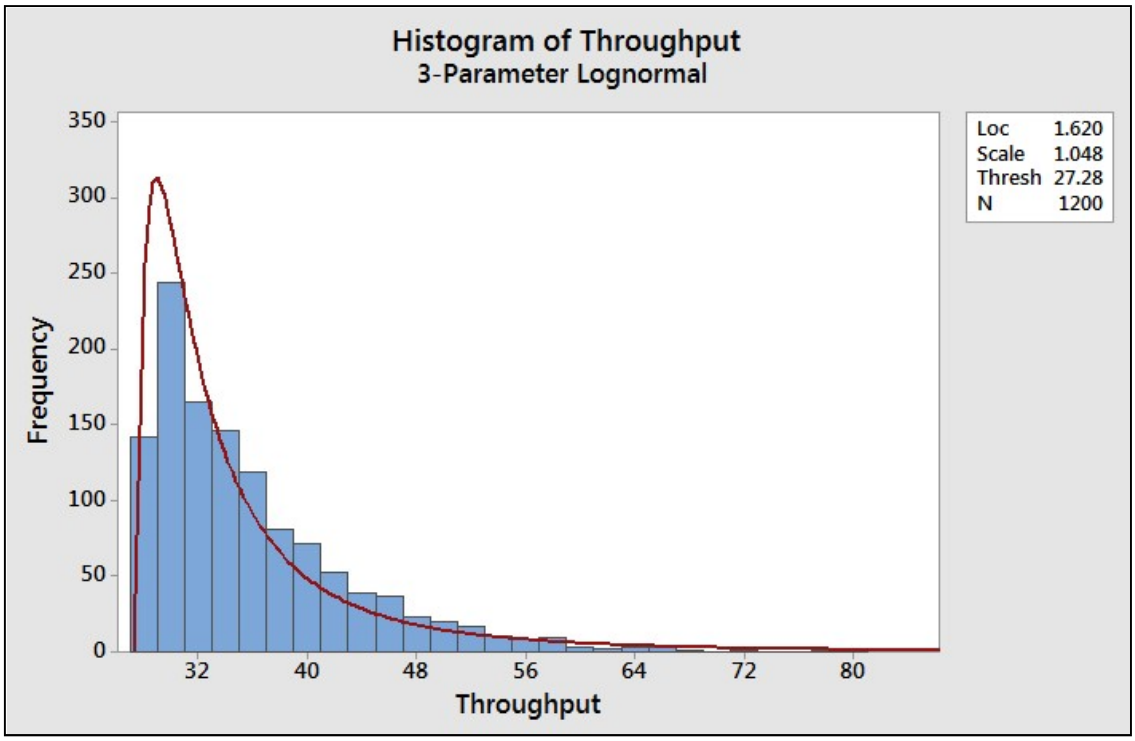


Figure 28—Analysis of Big Star's Throughput Times (Lead Times) in Days

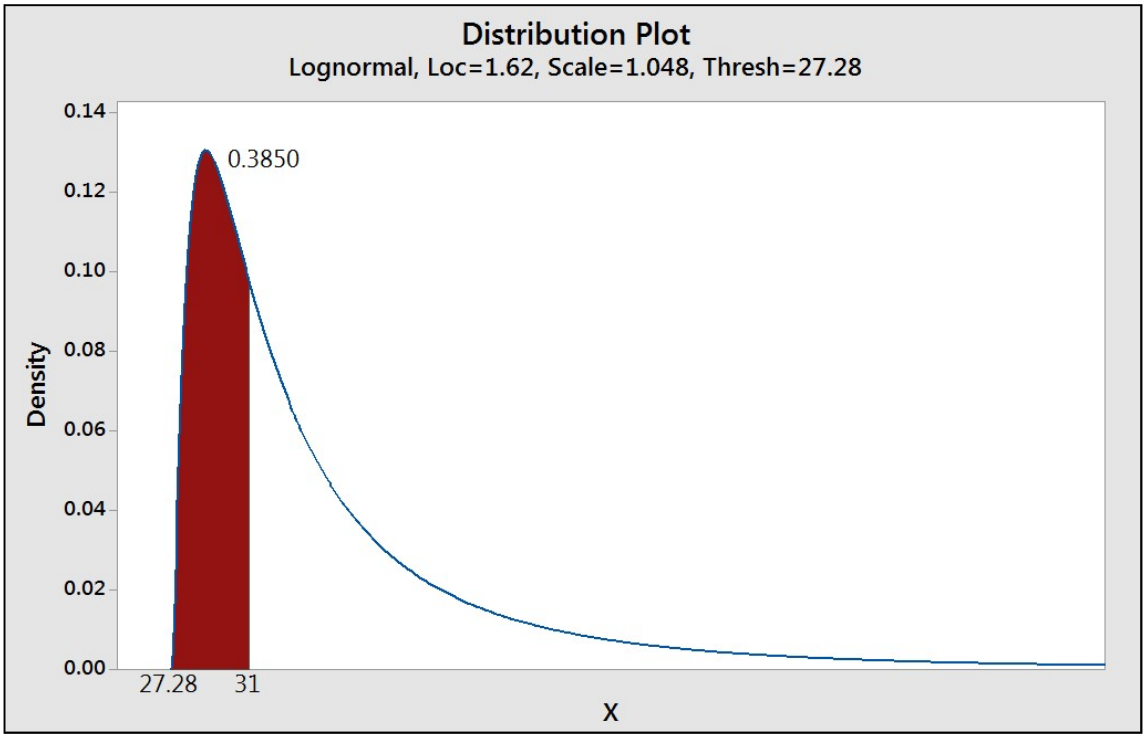


Figure 29—Profiling Big Star's Process Capability to Deliver on Time to Customers

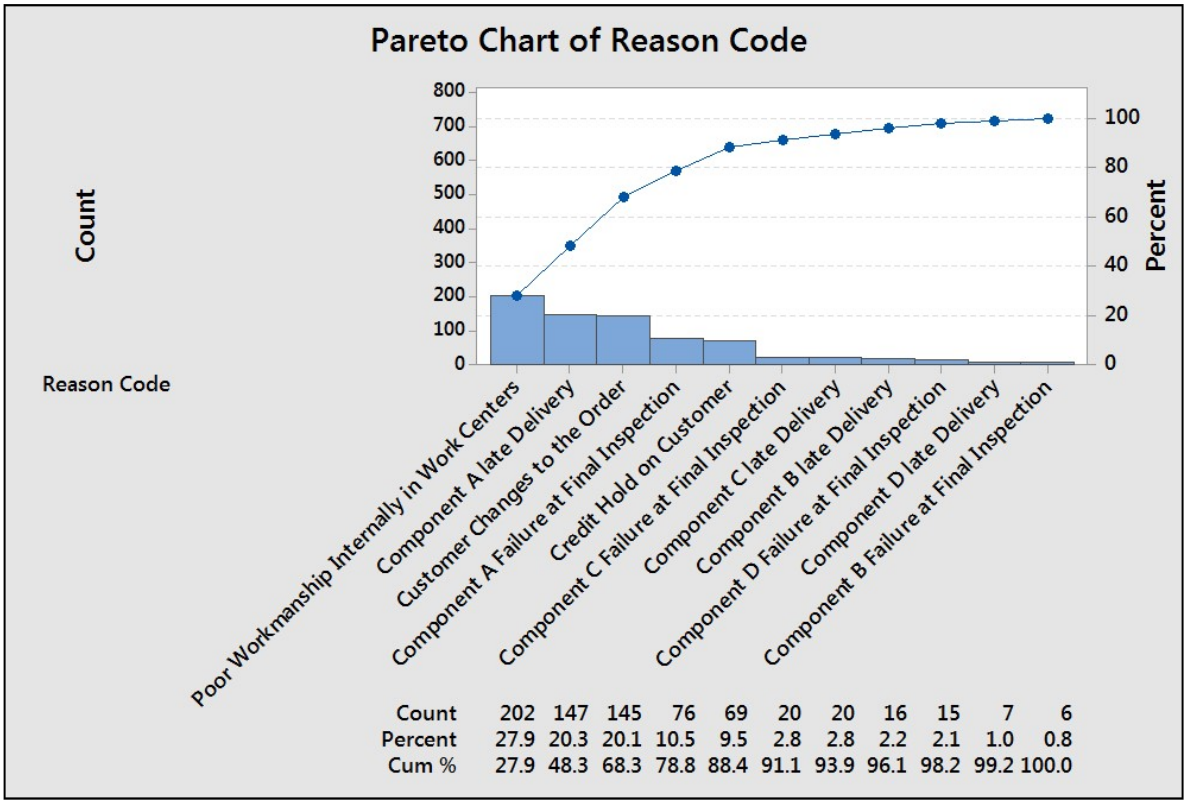


Figure 31—Pareto Chart Profiling Reasons for Late Delivery to Customers by Big Star

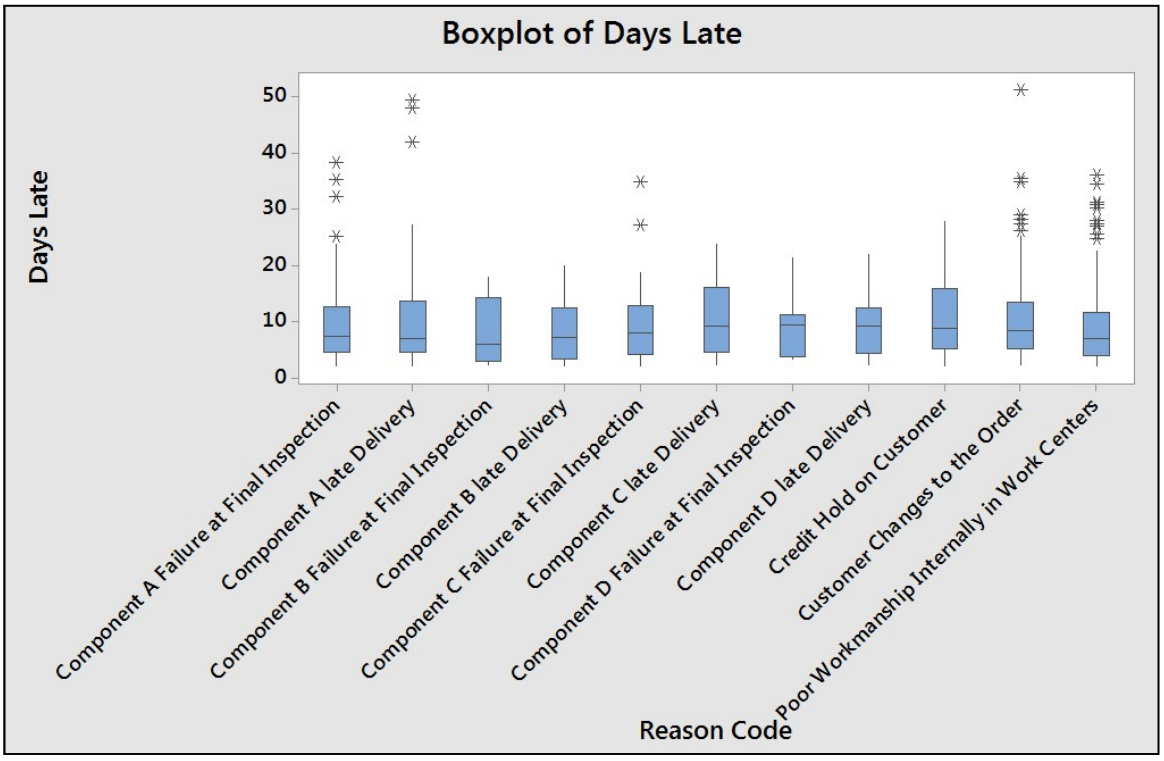


Figure 30—Impact on Big Star's Late Delivery by Reason Code

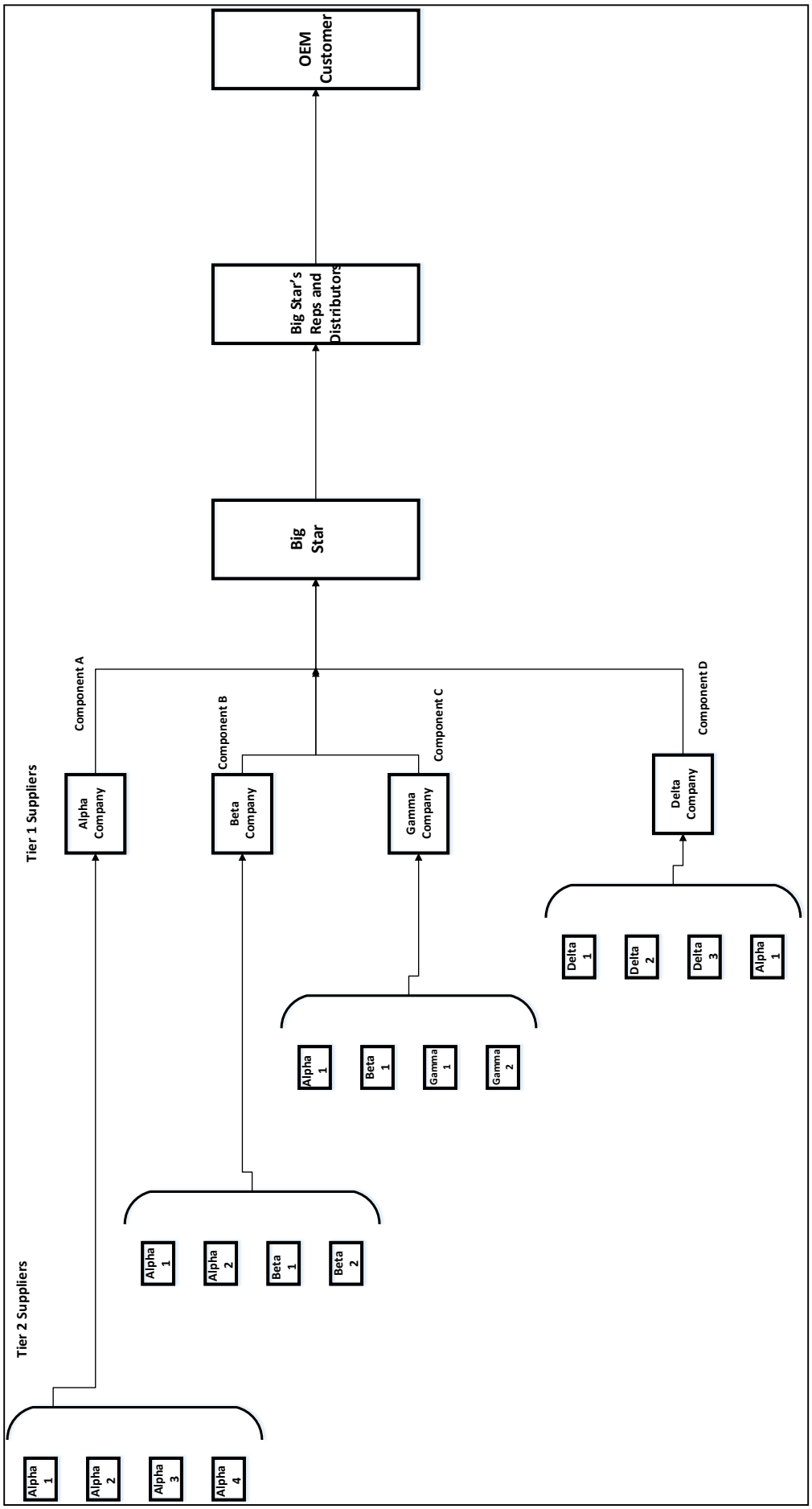


Figure 32—Jim's Depiction of the Supply Chain Network as He Prepares to Meet with Suppliers

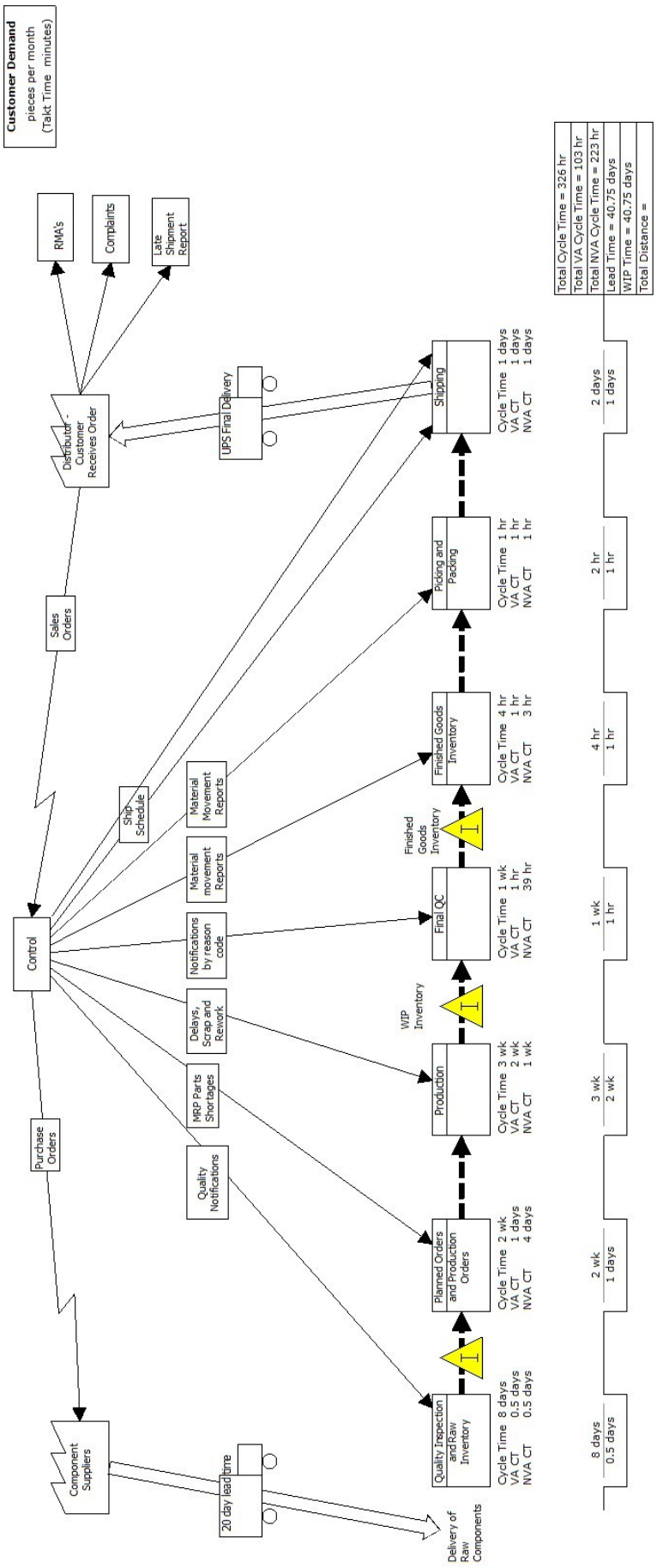


Figure 33—Value Stream Map Template from Minitab Quality Companion

Assignment 5 (For SCM Research and Data Science Students Only)

Meeting on Finished Goods Inventory, Lead Times and On-Time Delivery

In this assignment Jim is collaborating with Clive Jones, product manager for the 105 product line, as well as with Katherine Graves the Finance VP. Clive has performed market research and listening to the "Voice of the Customer" for his product line. From Clive's perspective the purpose of the meeting is to discuss reducing lead times and improving on-time delivery to customers. He shows his analysis of churn for his top customers. See Figures 35 and 36. Clive has confirmed that lead time reduction and on -time delivery improvements are essential to maintaining market share for his product line.

From Katherine's perspective the new ERP system has given the Finance organization new insights to an apparent excess inventory for finished goods across Big Star's 105 product line that is adversely effecting financials. From Katherine wants to explore opportunities to reduce inventory for finished goods Clive's product line as a top priority.

Katherine believes that even though Big Star is a make to order company, it keeps finished goods inventory like a make to stock company. As a result much of the current inventory is obsolete. Katherine shows the chart (Figure 34) to make her case for the 105 product line.

As VP of Supply Chain Jim takes charge of the meeting and formalizes the DMAIC project approach using the step by step roadmap in Minitab's Quality Companion Tool.

By following the DMAIC methodology Jim begins the project by leading the team to produce deliverables for the "Define and Scope" phase of work. Collectively the team decides that this phase requires completion of the following deliverables:

- Refinement of the CT Tree (from Clive)
- An idea map for on-time delivery improvement (Figure 36 is an example)
- An idea map for finished goods inventory reduction
- A fishbone diagram (i.e. cause-effect diagram) for on-time delivery improvement
- A fishbone diagram for finished goods inventory reduction
- A ballot to help the team agree upon priorities

Your Assignment

1) Follow the DMAIC project through the entire improvement life cycle using the Big Star data set provided and the tools made available in Minitab Quality Companion.

2) Assume that you are the product manager for the 259 product line. Using the inventory data files perform an analysis that produces reports similar to Figures 34 and 35 for those SKUs. Given the facts, what business strategy should be employed for these products.

3) Analyze the data set and build a prediction model for both on-time delivery and customer satisfaction for the 150 product line.

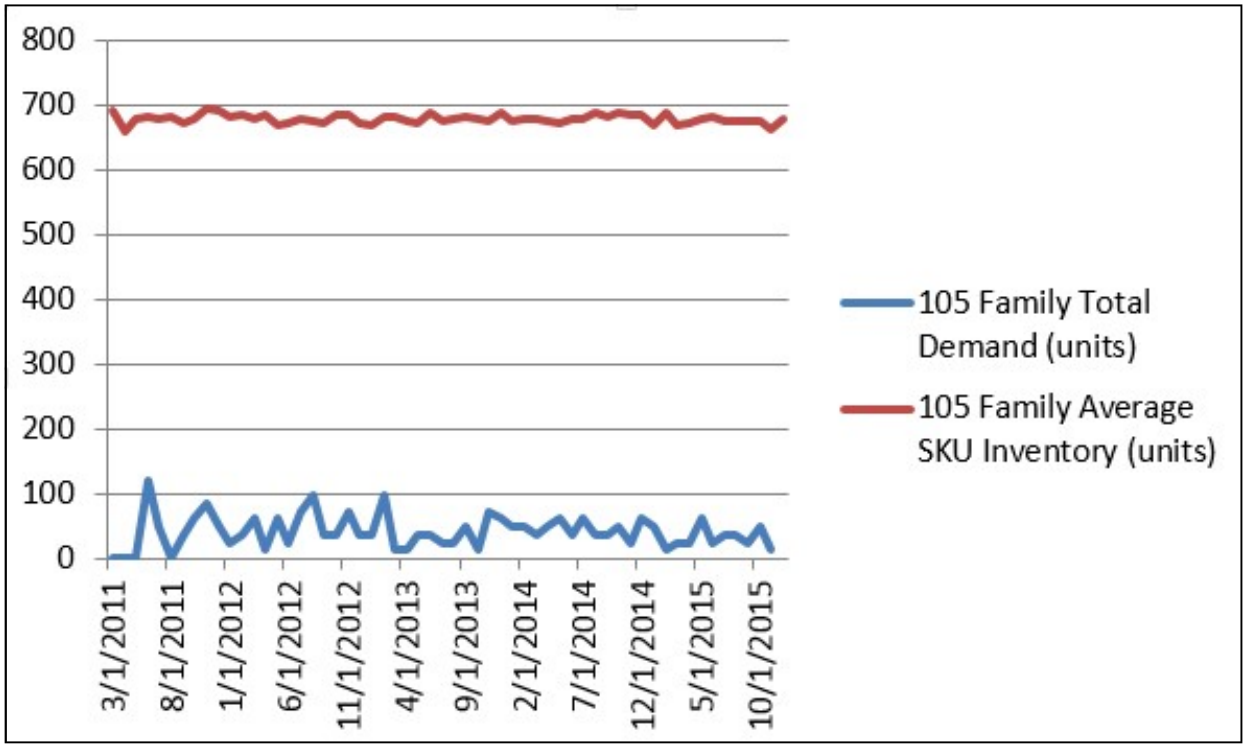


Figure 34—Katherine's Time Series Analysis of Shipments Versus Inventory for 105 Series Finished Goods

	Churn 150											
	No						Yes					
Customer-ID-Text	Avg. Satisfaction..	Avg. Days L..	Std. dev. of Days..	Avg. Discount	Total Revenue	Units Sold	Avg. Satisfaction..	Avg. Days L..	Std. dev. of Days..	Avg. Discount	Total Revenue	Units Sold
Distributor 2	3	8	12	0.128	414,795	732						
Distributor 1	5	4	5	0.089	348,204	588						
Distributor 3	5	8	12	0.160	176,803	324						
Distributor 4	7	2	4	0.100	63,206	108						
Distributor 5							6	6	6	0.058	66,134	108
Rep21							1	-1	0	0.075	28,864	48
Distributor 13							3	2	0	0.016	23,026	36
Distributor 14	10	3	2	0.037	15,021	24						
Distributor 16	7	3	0	0.129	13,592	24						
Distributor 17	2	-1	0	0.171	12,932	24						
Distributor 25							1	2	1	0.077	14,403	24
Rep12	5	1	1	0.052	14,785	24						
Rep2	8	5	4	0.186	12,704	24						
Rep4	9	7	6	0.139	13,432	24						
Rep8	7	3	4	0.131	13,562	24						
Distributor 6							2	10		0.220	6,085	12

Figure 35—Clive's Analysis of Churn for Customers to 150 product Line

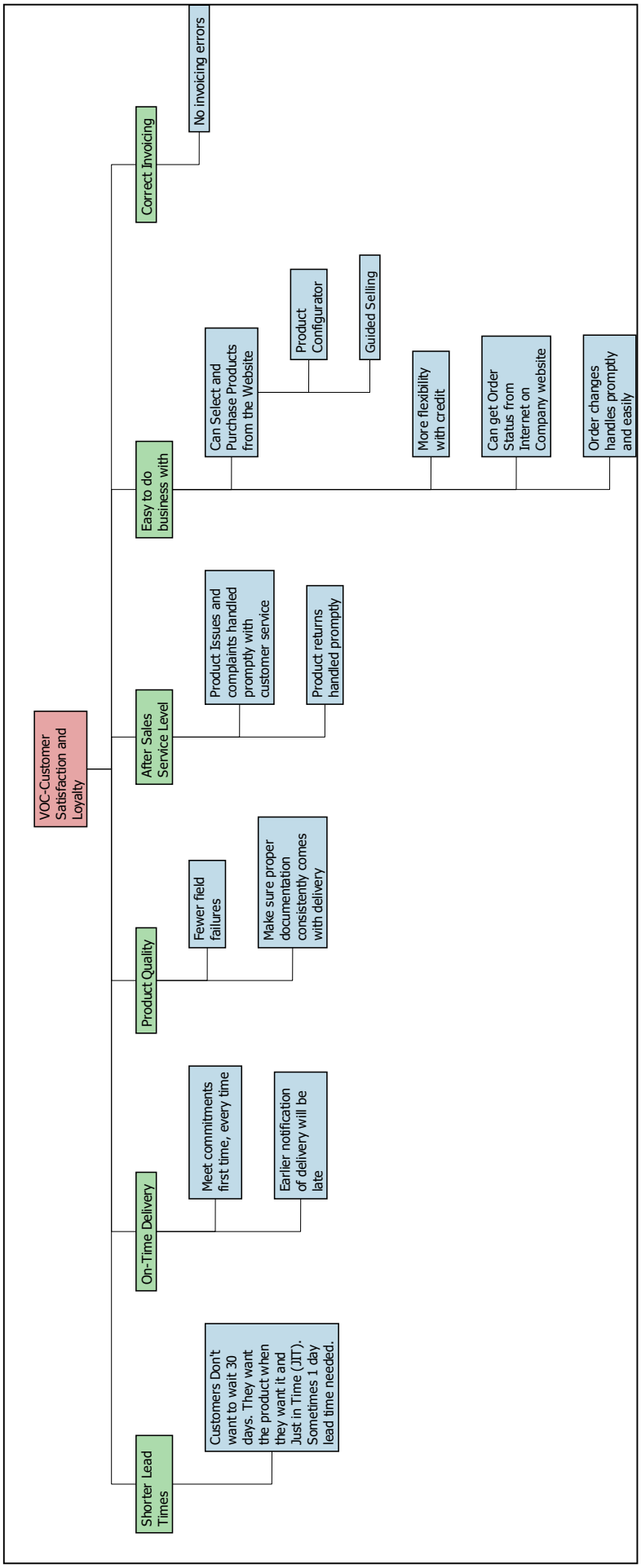


Figure 36—CT Tree Showing Results of Clive's Voice of the Customer (VOC) Research

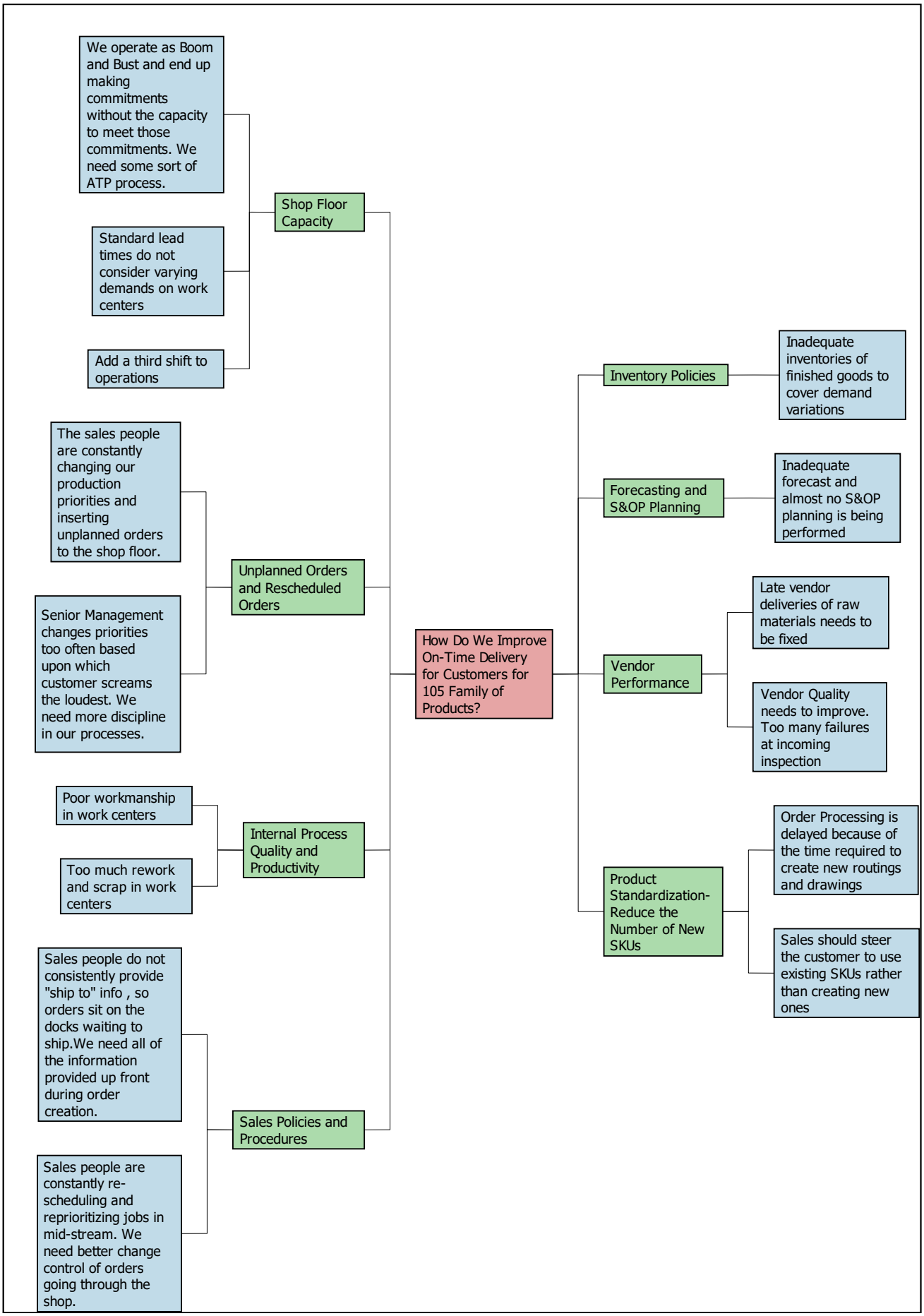


Figure 36-Idea Map for Improving On-Time Delivery

	2011										2012											
	Q1	Q2			Q3			Q4			Q1			Q2			Q3			Q4		
	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
Avg. 105-10047	1.700	1.476	1.636	1.727	1.905	2.435	2.045	2.048	1.636	1.500	2.364	1.667	1.727	2.524	1.957	1.905	1.773	1.957	2.250	1.913	2.045	2.381
Avg. 105-10053	2.700	2.429	2.000	1.636	2.095	2.304	1.864	2.524	1.727	2.045	1.909	2.524	2.773	2.095	2.087	2.429	1.909	1.783	2.000	1.826	2.136	2.524
Avg. 105-10054	2.700	2.238	1.909	1.591	1.476	1.826	1.864	1.857	1.591	2.091	2.000	1.810	2.636	1.762	2.087	2.095	1.955	1.261	2.250	2.174	2.091	1.619
Avg. 105-10058	2.400	3.143	2.818	3.591	3.000	2.913	3.045	2.524	3.000	3.182	3.091	3.048	3.455	3.095	3.348	2.619	2.955	2.870	3.250	3.739	2.500	3.714
Avg. 105-10061	2.800	3.000	2.727	2.773	2.762	2.783	3.318	2.905	3.273	3.500	2.864	3.000	3.045	2.571	2.739	2.714	3.227	2.826	3.050	3.435	2.909	3.095
Avg. 105-10083	6.500	5.143	4.909	5.500	6.048	4.870	4.591	4.762	4.455	5.318	5.591	5.095	4.500	4.905	5.391	4.381	4.636	3.913	5.150	4.087	5.000	5.429
Avg. 105-10090	5.300	6.143	6.227	5.364	5.286	6.870	5.818	6.714	6.091	5.636	5.500	5.857	5.364	7.000	6.870	5.762	6.227	6.348	5.500	5.870	6.182	5.381
Avg. 105-10092	5.500	5.952	5.864	6.000	5.048	6.435	4.682	5.429	5.636	6.818	6.500	5.524	6.091	6.095	5.783	6.714	6.591	5.870	5.250	6.435	6.864	5.952
Avg. 105-10105	6.100	7.048	6.182	6.273	6.095	6.478	5.455	5.095	5.818	6.727	7.045	5.000	5.636	6.286	6.087	5.286	5.773	6.130	4.850	6.261	6.091	6.429
Avg. 105-10107	6.600	5.952	5.773	6.045	6.667	5.304	5.909	6.381	6.455	5.955	5.955	5.619	5.909	6.952	5.609	5.857	6.182	6.304	5.250	6.130	5.455	6.095
Avg. 105-10114	2.900	1.857	2.182	1.727	2.048	1.565	2.000	1.952	1.909	2.500	2.591	2.000	2.000	2.667	1.957	2.000	1.864	1.652	2.000	2.478	1.773	1.286
Avg. 105-10117	2.500	1.286	1.773	1.909	1.952	1.913	2.136	2.190	1.909	2.455	2.273	1.857	1.955	2.095	1.870	1.667	1.955	2.217	2.200	2.130	1.818	1.952
Avg. 105-10123	1.900	1.762	1.818	1.455	1.857	2.435	1.545	2.000	2.136	2.136	2.000	1.857	1.500	1.476	1.652	2.143	1.909	2.478	2.100	1.652	1.864	1.429
Avg. 105-10129	1.500	2.048	2.364	1.682	1.857	2.130	1.818	1.667	2.136	2.636	2.409	2.000	1.636	2.476	2.130	1.762	2.318	2.130	1.750	2.043	2.591	2.238
Avg. 105-10135	[illegible]	[illegible]	2.773	3.591	3.143	2.217	2.909	3.095	3.182	3.045	2.545	3.429	2.318	2.762	2.391	2.524	2.545	2.826	[illegible]	2.783	2.773	[illegible]

Figure 37 —Partial View of Big Star Average On-Hand Inventory by month for SKUs in 105 Product Line

Year of Commit Date	Quarter of Commit Date	Month of Commit Date	105-10047	105-10053	105-10054	105-10058	105-10061	105-10083	105-10090	105-10092	105-10105	105-10107	105-10114	105-10117	105
2011	Q2	June	120												
	Q3	July		12	12	12	12								
		September						12	12	12					
	Q4	October									12	12	12	12	
		November													
		December													
2012	Q1	January													
		February													
		March													
	Q2	April													
		May													
		June													
	Q3	July													
		August													
		September													
	Q4	October													
		November													

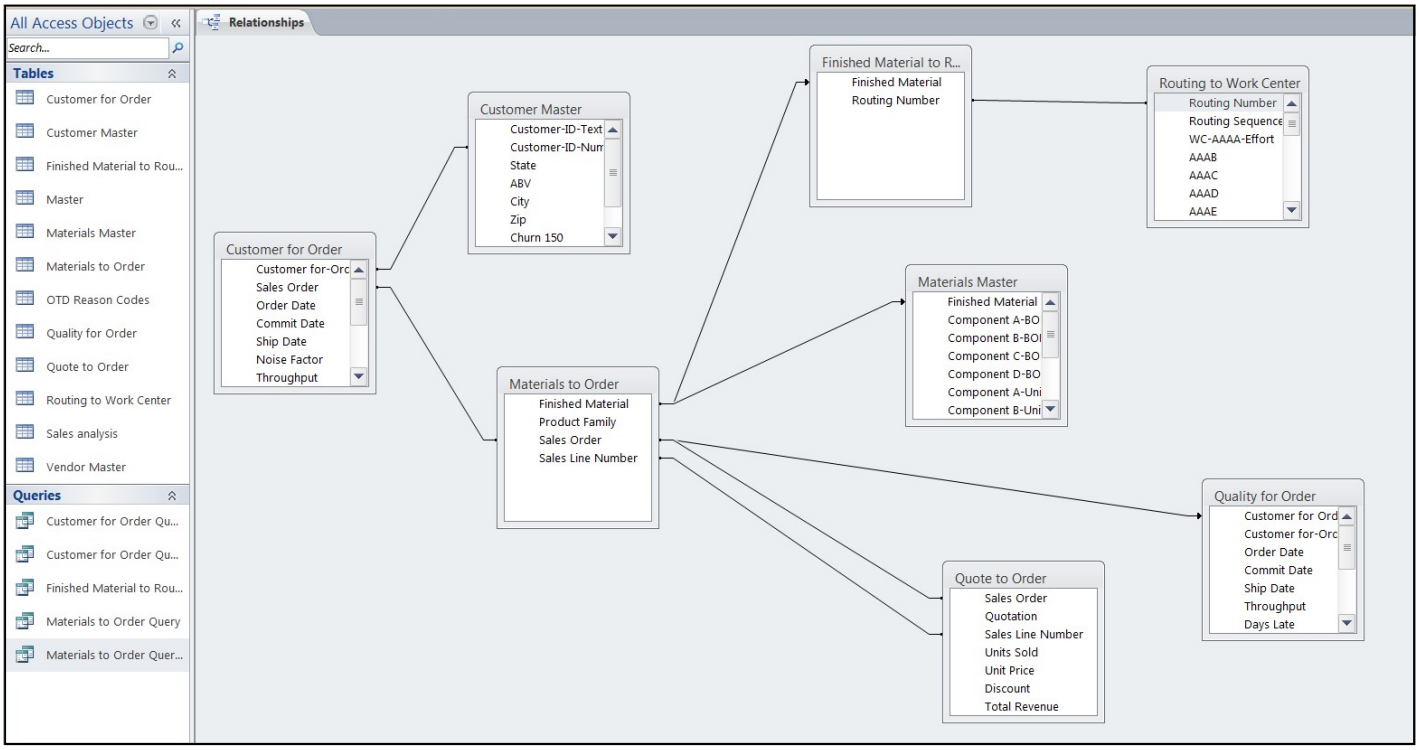
Figure 38 —Partial View of Big Star Sales-Demand By Month for SKUs in 105 Product Line

Appendix to Assignment 5

Screen Shots of Analytical Reports on the 150 Product Line

Figures 37 through 44 on the following pages provide the results of exploratory data analysis for on time delivery of Big Star's 105 product line.

MDS Students and SCM research students can access the data by running queries frpm the sample data base consisting of the tables shown below.



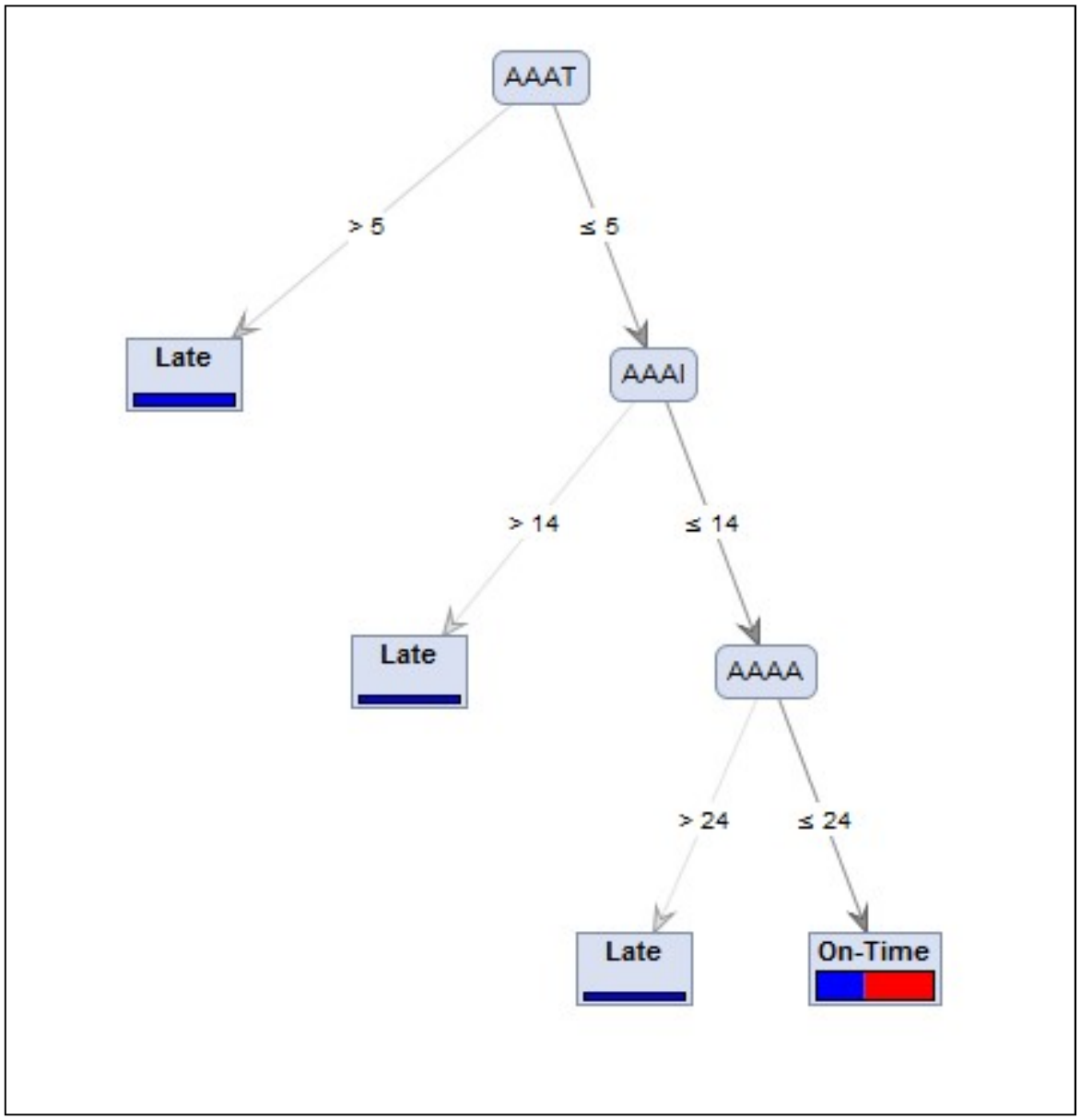


Figure 37: Big Star 105 Product Line Classification Tree for Late vs On-time Delivery to Customers (Rapid Miner tool)

accuracy: 100.00% +/- 0.00% (mikro: 100.00%)

	true Late	true On-Time	class precision
pred. Late	110	0	100.00%
pred. On-Time	0	83	100.00%
class recall	100.00%	100.00%	

Figure 38: Big Star 105 Product Line Classification Tree Prediction Accuracy for In Sample Observations (Rapid Miner tool)

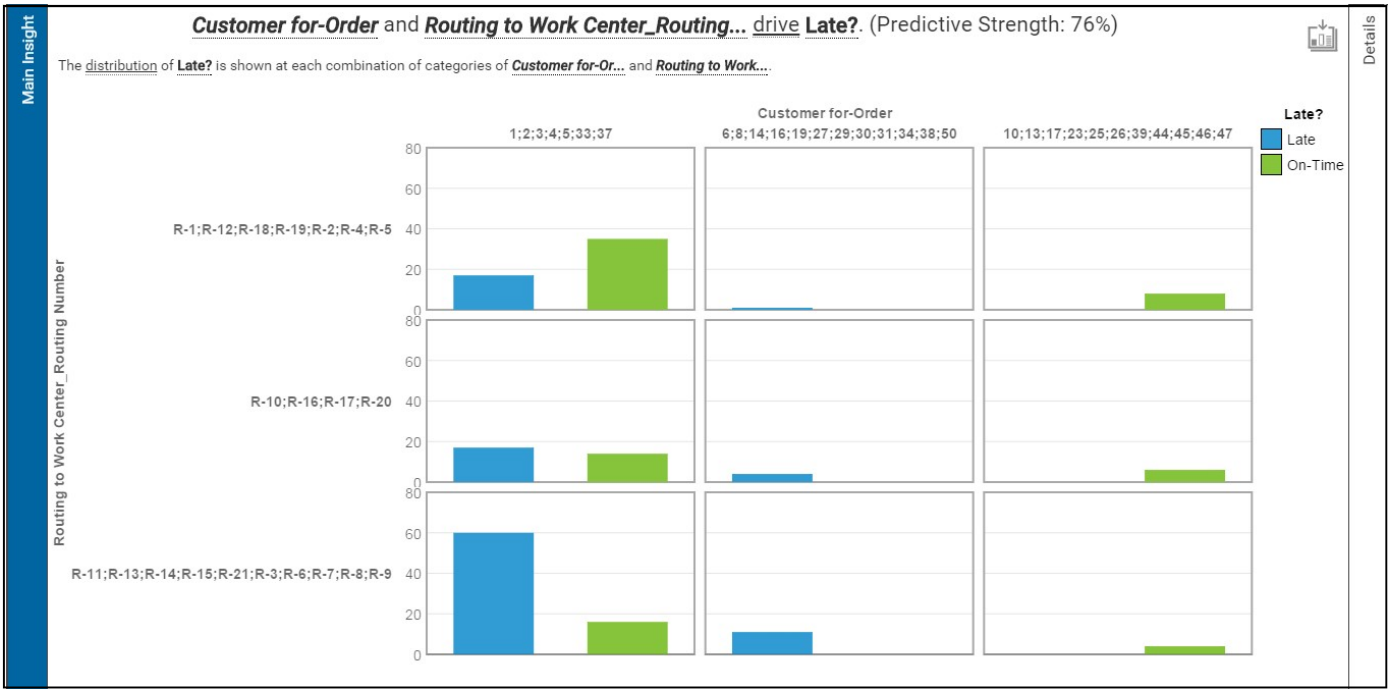


Figure 39: Big Star 105 Product Line Exploratory Analysis of On-Time Delivery by Routing By Customer (IBM Watson tool)

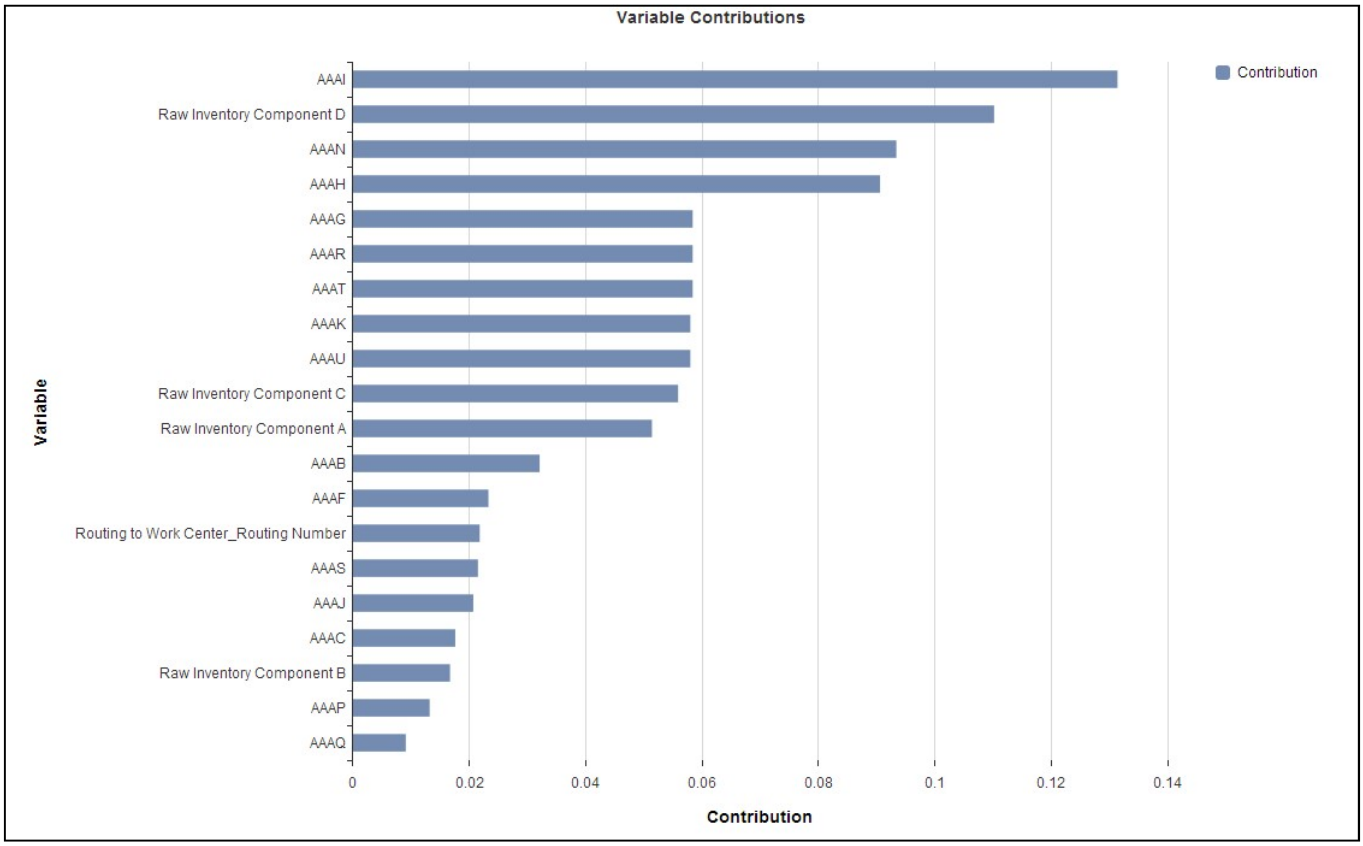


Figure 40: Big Star 105 Product Line Exploratory Analysis of On-Time Delivery by Variable Contribution (SAP Predictive Analytics tool)

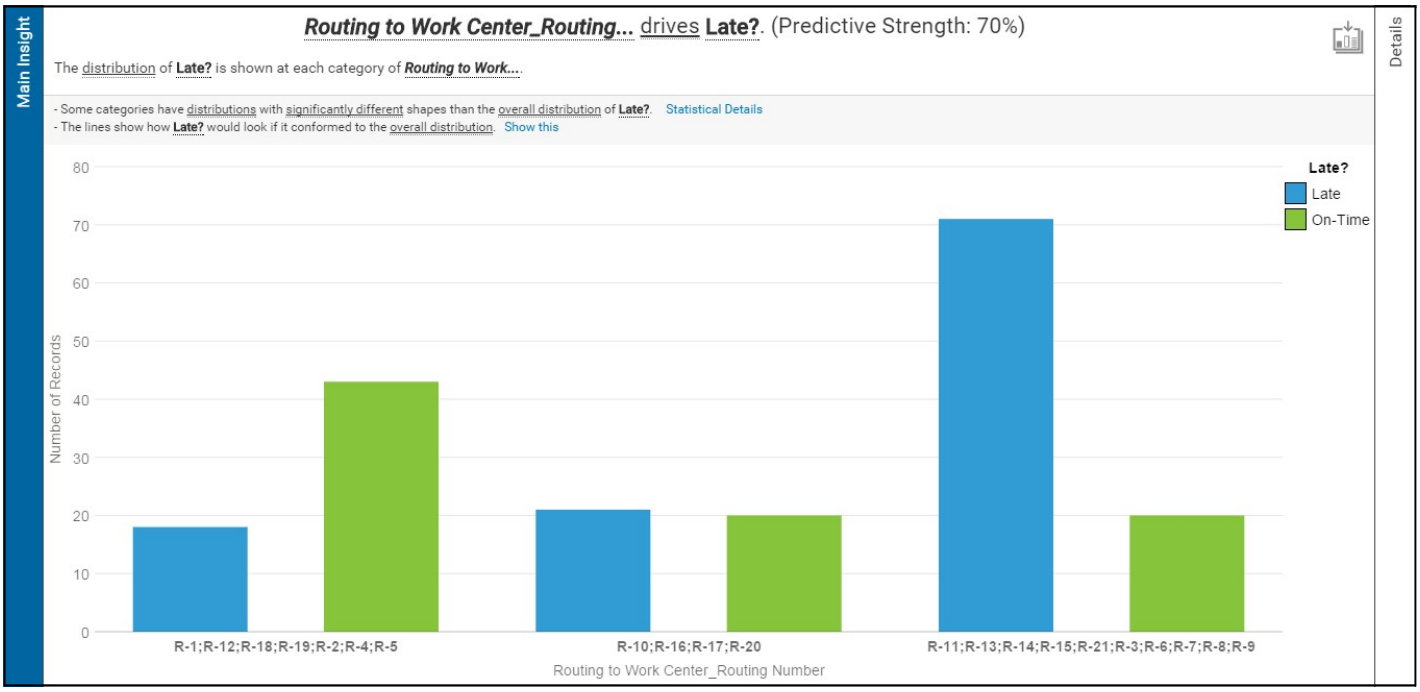


Figure 41: Big Star 105 Product Line Exploratory Analysis of On-Time Delivery by Routing (IBM Watson tool)

Figure 42: Big Star 105 Product Line Exploratory Analysis of On-Time Delivery by Routing By AAAI work center labor hours (IBM Watson tool)

Figure 43: Big Star 105 Product Line Exploratory Analysis of On-Time Delivery by Routing By AAAT work center labor hours (IBM Watson tool)

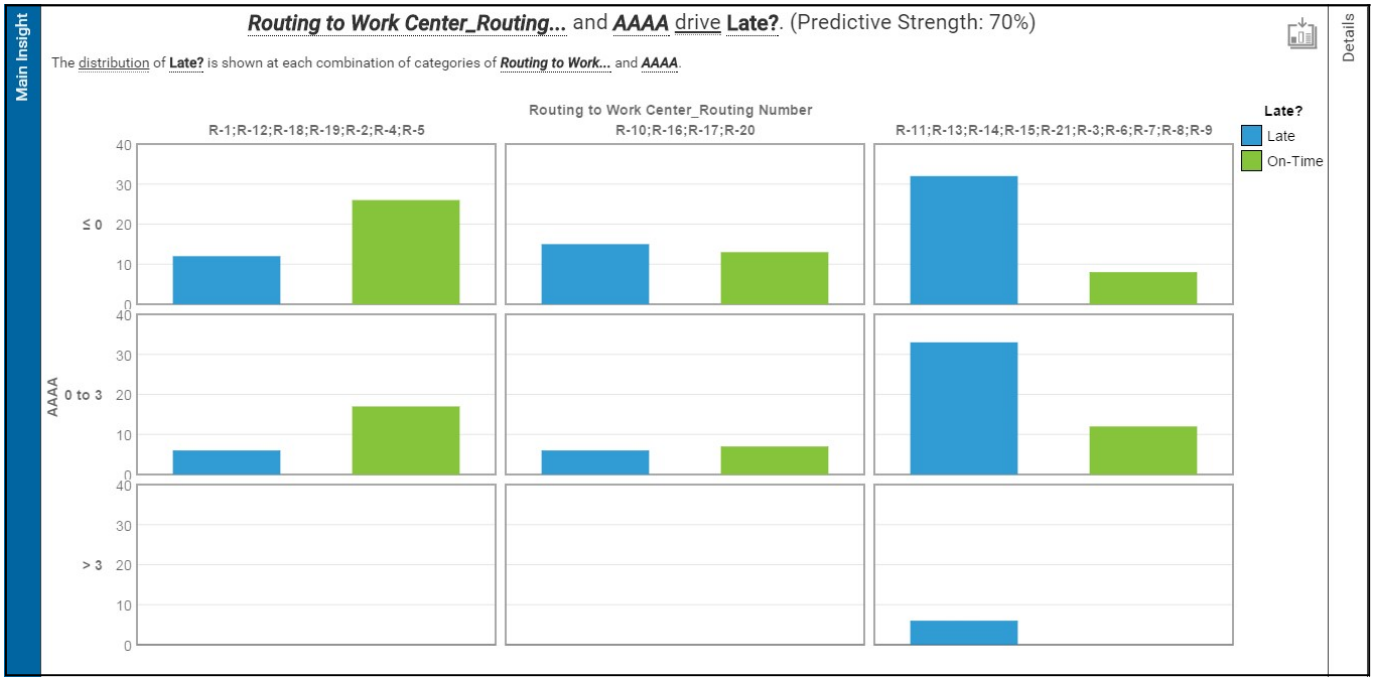


Figure 44: Big Star 105 Product Line Exploratory Analysis of On-Time Delivery by Routing By AAAI work center labor hours (IBM Watson tool)

Assignment 6 (For SCM Research and Data Science Students Only)

Meeting on Sales Effectiveness

In this assignment Jim is collaborating with Betty Clark, sales manager for the 105 product line, as well as with Katherine Graves the Finance VP. Betty used the data in the CRM and ERP Systems is using data mining and predictive modeling to improve the rate of conversions of sales leads into actual sales. In this assignment Betty is walking through her approach with Jim to obtain his feedback.

Your Assignment

1) Review Betty's analytical approach shown below. Do you agree with the approach?
2) Can you make suggestions for improvement in her research and analytical methodology?

The Approach

The emergence of data science as a formal business discipline brings with it the evolution of the scientific method. In today's world of big data the successful solution of business problems assume the use of existing data as the starting point in the creation of new knowledge and information gain that drives action toward improving the competitiveness of the organization. To accomplish this it is important for the student to become comfortable with the three types of reasoning as defined by Charles Peirce[1]. These are:

a) Abductive reasoning is reasoning from given data to a hypothesis explaining the data. Abductive inference is most often used at the discovery stage of scientific hypothesis formation and testing. Abduction suggests that something *may be*. It is an intelligent guess tied to an incomplete body of evidence that may or may not be sufficient to guide action. Abductive inference infers a probability. It is often followed by either deductive inference or inductive inference (or both) for theory testing after sufficient data become available.

Charles Peirce's classic example of abductive reasoning is:

Premise One: All the beans from this bag are white.

Premise Two: These beans are white.

Conclusion: These beans are from this bag.

b) Deductive reasoning begins with a hypothesis assumed to be true. It proves that something *must be*, as it is based upon identifying the logical consequences and deduced predictions of an established premise. Deduction is the second step

of the inferential cycle.

Peirce's example of deductive reasoning is:

Premise One: All the beans from this bag are white.

Premise Two: These beans are from this bag.

Conclusion: These beans are white.

c) Inductive reasoning links prediction to a theory. To use Peirce's terms "induction consists in starting from a theory, deducing from it predictions of phenomena, and observing those phenomena in order to see how nearly they agree with the theory." In this regard induction is the third step of the inferential cycle.

Peirce's example of inductive reasoning is:

Premise One: These beans are from this bag.

Premise Two: These beans are white.

Conclusion: All the beans from this bag are white.

Figures 45A and 45B reflect an adaptation to Minnameier's [2] inferential model that operationalizes these constructs. Here we provide a comparison between the traditional and current views of the application of data science to business. Following the current view as shown in Figure 45B we start the investigative cycle at time ❶with a surprising event or a business problem that needs resolution. We then use available data develop a set of efficient explanatory hypotheses that best explain the data, and these become our theory ❷. As part of the development of our theory we make a determination as to whether adequate facts exist to go directly to action for resolution of the problem. This is a critical determination that follows Peirce's pragmatic philosophy since data do not need to be perfect to be sufficient for action. Assuming that more analysis is needed we move to step ❸ we operationalize our theory by deducing the logical consequences of it to a set of predictions assuming the theory is true. Then ❹ we observe experiments, add additional data and make comparisons allowing us to assess the accuracy of our predictions. We can then make statements about how generalizable our theory is. Then ❺ as we continue to add additional observations (i.e. evidence) to our testing, we can make further statements regarding the validation of new knowledge and information gain. As our sample of observations grows, the weight of evidence increases to the point that we have gained enough confidence to take action leading to problem resolution and business improvement❻.

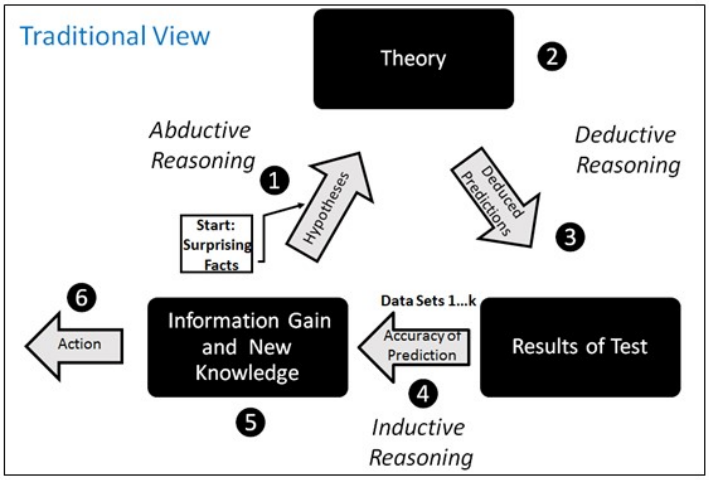


Figure 45A

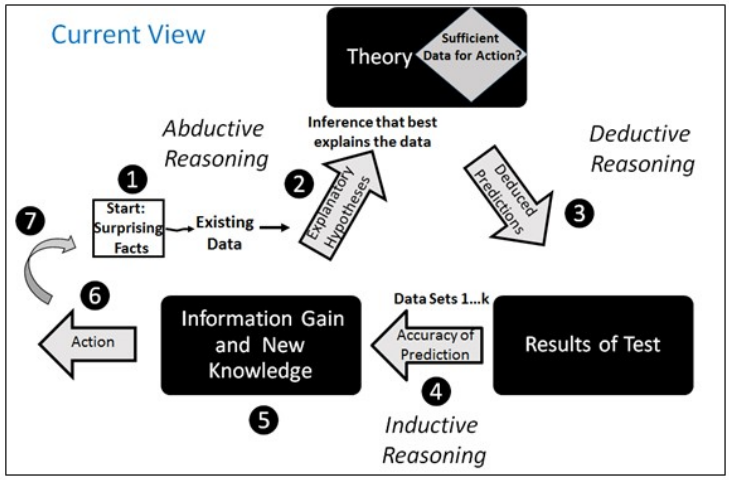


Figure 45B

The simulated business case "Big Star Assemblies, Inc." facilitates the adoption of the scientific method in a data science context especially when used in conjunction with established improvement methodologies such as Lean Six Sigma (DMAIC).

We will demonstrate a very simple example showing how this approach works using simulated data set with the cycle shown in Figure 45B above and within the context of supply chain management.

We start the example by assuming that we are a new sales manager at Big Star Assemblies, Inc. who is challenged by his or her boss to improve the effectiveness of the sales team. To the sales manager's chagrin, the sales team is converting only 7.6% of the sales leads into actual sales according to an available report from the company's IT system. The sales manager has a choice of either winging it (i.e. doing what was done at a previous job) or taking a more scientific approach by looking at the facts surrounding the problem at hand.

One of the data tables in the Big Star case study database contains customer relationship management (CRM) data in a structured format. Fields available include variables such as sales leads on prospective customers, the source for each sales lead, closure rates, sales office locations, number of sales criteria met by the sales person, the number of follow up contacts by the sales person for each prospect, etc. We will apply the steps articulated in Figure 45B above to this table as our example.

❶ Start: Preliminary Data Analysis and Development of Explanatory Hypotheses

Each record in our CRM table is a sales lead. Our objective is to improve the conversion rate of sales leads by our sales team. Our target variable is whether or not we converted that lead into an actual sale. We can use our experience to create explanatory hypotheses, but it is better to augment that experience with facts obtained from a quick scan of the historical sales leads database containing 235 records by using visual tools such as IBM's Watson Analytics, Tableau or SAP's Lumira. For purposes of this example we will use the IBM Watson cloud tool.

The results as shown in Figure 46 below indicate that *"the number of sales criteria met"* appear to be the single most powerful predictor of whether or not a sales lead gets converted into an actual sale. Also the *"number of follow up attempts"* by the sales person appear to be highly correlated with *"the number of sales criteria met".* This finding matches the sales manager's experience. So the manager develops the hypothesis and theory that: 1) by increasing the sales team's adherence to the sales methodology, 2) by increasing sales effort as measured by criteria met and 3) by increasing the frequency of follow up by sales persons, an increase in the closure rate of sales deals will occur.

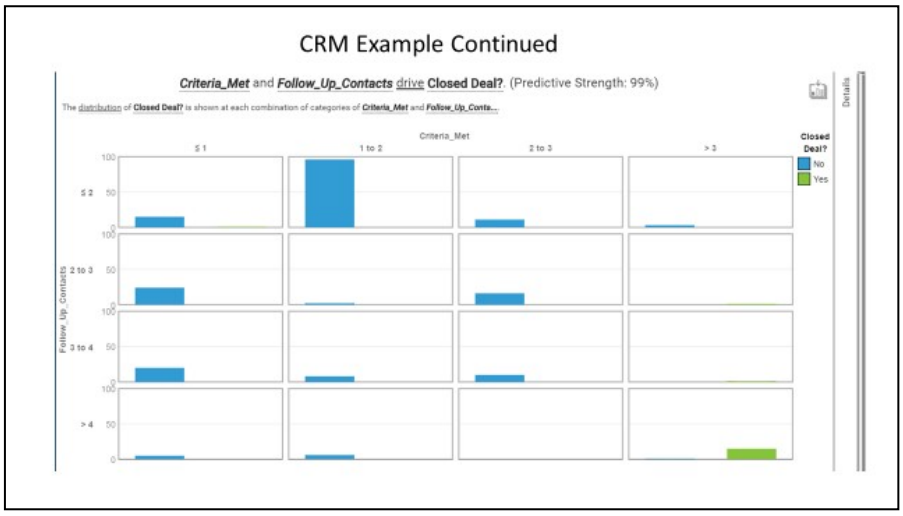


Figure 46

❷ The results are insightful for the sales manager. However the sales manager is concerned that other variables may impact how generalizable these results are. For instance the manager believes that the sales office and the source of the lead may moderate the sales person's ability to follow up on sales leads and achieve the criteria needed to close the sale. Therefore, the sales manager concludes that more analysis and more data are needed before developing an action plan.

❸ The sales manager deduces that the team will be able to test the predictive accuracy of the theory by building a statistical regression model and then by observing an improvement in accuracy against a baseline random prediction (based upon the known 7.6% conversion rate). The table below shows the results of that simulation which indicates that the random model predicted correctly 202 out of 218 lost sales opportunities, but it only predicted correctly 2 out of 17 leads that were successfully converted to actual sales. Based upon this finding the sales manager believes that by using the statistical regression model the team's predictive accuracy will improve dramatically if the premises of the theory are true.

	Random		
Sales Lead	0	1	Total
0	**202**	**15**	**217**
1	**16**	**2**	**18**
Total	**218**	**17**	**235**

❹ Next, the team runs a regression model to test the predictive accuracy obtained after including *"the number of sales criteria met"* as well as the *"number of follow up attempts"* into the analysis. The results of the analysis are shown in the table below and in Figure 47. We see that all variables included in the model are statistically significant (Figure 4) and that our predictive accuracy over the 235 sales lead sample has improved substantially. As shown in the table, the regression model predicted correctly 217 out of 218 lost sales opportunities, and it predicted correctly 17 out of 17 leads that were successfully converted to actual sales.

	yhat5		
Sales Lead	0	1	Total
0	**217**	**0**	**217**
1	**1**	**17**	**18**
Total	**218**	**17**	**235**

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SalesLead <-						
Criteria_Met	.1262989	.0043387	29.11	0.000	.1177951	.1348026
_cons	-.2249092	.0131387	-17.12	0.000	-.2506606	-.1991579
Criteria_Met <-						
Follow_Up_Contacts	.6457464	.0586743	11.01	0.000	.5307469	.7607459
Sales_Office_South	-1.023279	.2076957	-4.93	0.000	-1.430355	-.6162032
Source_Campaign	-.4136239	.1995861	-2.07	0.038	-.8048055	-.0224424
_cons	1.246106	.2364203	5.27	0.000	.7827308	1.709481
var(e.SalesLead)	.0153563	.0014167			.0128162	.0183998
var(e.Criteria_Met)	2.161133	.1993713			1.803663	2.58945

Figure 47

❺ Before taking action the sales manager decides to wait and obtain additional data in order to try out the predictive accuracy against the new observations. So, after a short waiting period the manager obtains 44 additional (new) data points and observes the model's predictive accuracy. The results of the analysis are shown in the table below and suggest that the model predicted all 44 new observations correctly. In addition the measures of information criteria (Akaike) indicate that the model is a decisive improvement over the random model. The sales manager is now confident that it is time to take decisive action to improve the process.

	yhat8		
Sales Lead	0	1	Total
0	**42**	**0**	**42**
1	**0**	**2**	**2**
Total	**42**	**2**	**44**

❻ The sales manager now continues along the Six Sigma DMAIC life cycle to improve and control the business process.

Next we assume that perhaps in steps ❹ and ❺ the accuracy of prediction was less than the sales manager had hoped. So, the sales manager returns to step ❷ and uses abductive reasoning by performing qualitative research for development of other explanatory hypotheses and theory.

So by performing this research the sales manager uncovers information that suggest the sales methodology should also consider the social dynamics that exist within the potential customer organizations. Consequently it is not only important that the manager ensure that a sufficient number of follow up contacts are made in general, but it is also important that those contacts are targeted to all of the people who influence the buying decision. The manager hypothesizes that to raise the probability of converting a sales lead into an actual sale, the sales people need to systematically make contact with all of the *key influencer roles* within the organization as shown at the bottom of Figure 48 on the following page. The manager hypothesizes that right now the sales team is only contacting *Diversity Generators* while ignoring all others as portrayed in the social network as shown in Figure 48.

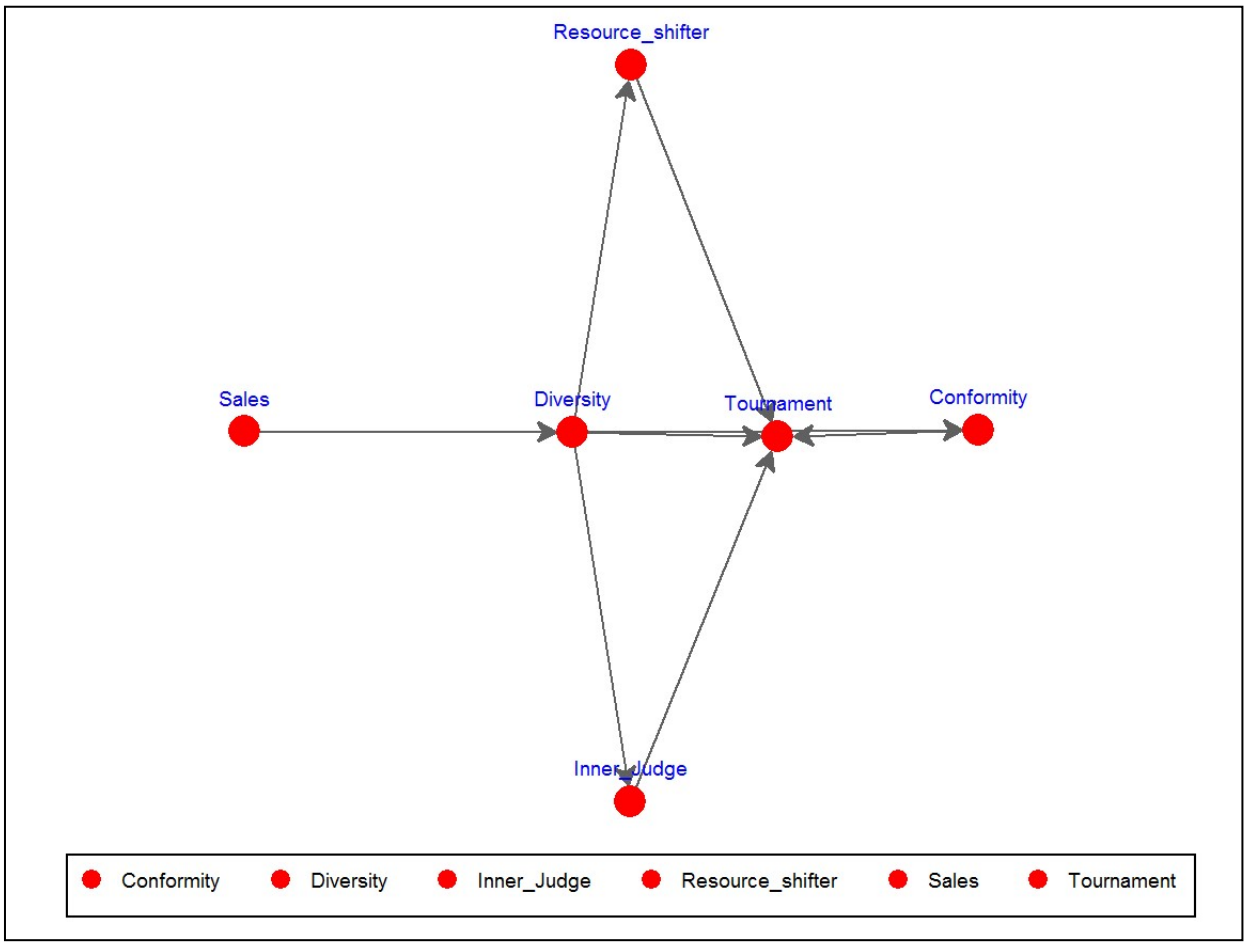


Figure 48

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