The Johnson and Johnson Journey Deploying SmartOps for Multi-Echelon Inventory Optimization

By

Arnita Hayden
B.S. Computer Engineering, Howard University, 2008

Submitted to the MIT Sloan School of Management and the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degrees of
Master of Business Administration
and
Master of Science in Engineering Systems
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ABSTRACT

Multi-echelon inventory technology enables firms to significantly reduce inventory costs. It gives managers the ability to make tradeoffs based on information from the entire supply chain, which results in a more powerful supply chain strategy and stronger competitive advantage. This thesis provides a case study exploring the deployment of SmartOps multi-echelon inventory optimization technology in Johnson and Johnson's Medical Devices and Diagnostics supply chain.

The basis for this thesis is an internship project that focused on implementing SmartOps in the Transfusion Medicine and Mainframe Slides businesses within Ortho Clinical Diagnostics, a group within the Medical Devices and Diagnostics sector. Through a pilot program, this internship analyzed the level of complexity involved in deploying multi-echelon inventory optimization tools such as SmartOps. In addition, this internship identified key challenges associated with data quality, especially in decentralized supply chains.

The results of this study show that while IT investment decisions are challenging, senior executives should strongly consider investing in multi-echelon inventory optimization software. Recommendations for implementation include automation, people development, and forecast data centralization.

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1 Introduction

The objective of this thesis is to provide a case study exploring the deployment of SmartOps multi-echelon inventory optimization technology in enterprise supply chains. This thesis will provide considerations for implementing SmartOps in a decentralized organization such as Johnson and Johnson's Medical Devices and Diagnostics sector. Ortho Clinical Diagnostics is a group within the Medical Devices and Diagnostics sector. The basis for this analysis is an internship project that focused on implementing SmartOps in the Transfusion Medicine and Mainframe Slides businesses within Ortho Clinical Diagnostics. Only subsets of products were selected for the initial phase of this project. Therefore, in this thesis we will refer to this internship project as a pilot. Implementing this pilot allowed Ortho Clinical Diagnostics to evaluate the feasibility of implementing SmartOps across all business units.

Multi-echelon inventory optimization literature agrees that inventory optimization vendor technologies enable supply chains to make better tactical decisions. However, what are the risks in regards to data quality? Also, inventory modeling in SmartOps, or any vendor technology, is a specialized skillset. Can companies develop this competency internally? This study attempts to answer these questions by validating the level of complexity involved in deploying multi-echelon inventory optimization tools such as SmartOps.

1.1 Thesis Overview

In this thesis Johnson and Johnson will be referred to as J&J and Ortho Clinical Diagnostics will be referred to as OCD.

This thesis proceeds as follows:

- **Chapter 1** explains the drivers behind multi-echelon inventory optimization and the current industry landscape of inventory optimization software. It also contains a brief description of SmartOps
- **Chapter 2** provides background information on J&J and OCD, and describes the objective for this internship project

- **Chapter 3** describes SmartOps at a high-level and describes the inputs required to perform a SmartOps run
- **Chapter 4** explains the process we used to build the OCD SmartOps model
- **Chapter 5** discusses some of the model results and methods we used to verify the model
- **Chapter 6** briefly discusses some of the methods for implementing the model's results
- **Chapter 7** includes conclusions, next steps, and recommendations

1.2 Multi-echelon Inventory Optimization

In a local (one-echelon) inventory optimization strategy, each node tries to optimize profit with very little regard to the impact that their decisions have on other stages in the same supply chain. A local strategy helps a single facility manage its inventory in order to minimize the facility's own cost as much as possible (Simchi-Levi, Kaminsky and Simchi-Levi). However, optimizing each node locally ignores the fact that inventory decisions at every point in the supply chain are linked.

Most supply chain networks today are global, and consist of raw materials, work-in-process inventory, and finished goods that flow between multiple suppliers, manufacturing plants, and warehouses. Inventory at each node in the network, impacts inventory at every other node in the network. As a result, local inventory strategies are no longer sufficient to manage today's global and complex supply chains. Companies must adopt a multi-echelon inventory optimization strategy to significantly reduce inventory costs while maintaining or decreasing service levels to customers.

Most enterprises have supply chain leaders that understand the need for multi-echelon inventory optimization. However, the challenge for most enterprises, is figuring out how to implement a multi-echelon strategy. Information technology is an important enabler of effective supply chain management (Simchi-Levi, Kaminsky and Simchi-Levi). In this thesis, we will argue that the best way to implement a multi-echelon strategy is to utilize information technology. This technology can be developed in-house or purchased from external software vendors. However, we will focus on the benefits of utilizing external vendor multi-echelon inventory technology.

1.3 Multi-echelon Inventory Optimization Technology

IT funding decisions are long-term strategic decisions that impact a firm's operating model (Ross and Weill). IT investment decisions are challenging, however senior executives should strongly consider investing in multi-echelon inventory optimization software. In addition to significantly reducing inventory costs, this technology also gives firms the ability to view their inventory levels end-to-end from a single point of contact. It also enables managers to make tradeoffs based on information from the entire supply chain, which results in a more powerful supply chain strategy and stronger competitive advantage.

The multi-echelon inventory optimization software industry includes vendors such as, Opiant, SmartOps, Logictools, and GainSystems. These vendors help organizations deal with the complexity of managing multi-echelon supply chains by using sophisticated algorithms and modeling.

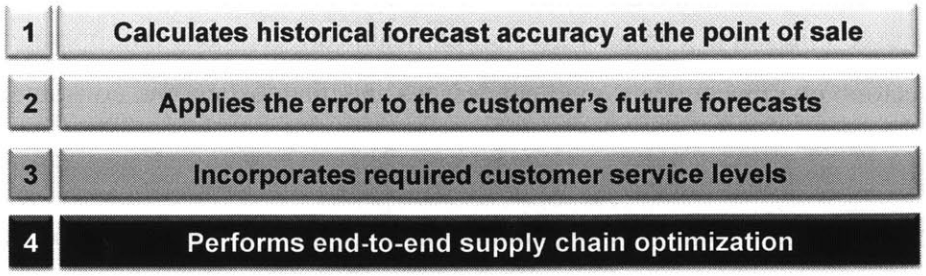
> *Inventory optimizers, like SmartOps, bolt onto and work alongside ERP or supply-chain management systems. "It's not like you have to disrupt your internal organization or tear your technology upside down," says Enslow [Beth Enslow, vice president of enterprise research at Aberdeen]. "But you have to have the data about your supply chain. For some companies, that's still a lot of work. For others, who have better information, it's not that big of a deal."* (Hasselt)

Mostly all of the vendor solutions determine optimal inventory of each product, as well as location for each product and time. They can handle multistage nonlinear relationships, time-varying capacity constraints and stochastic variables for thousands of items. However, SmartOps rises to the "top of the pack" due to capabilities such as "what-if" analysis and forecast accuracy calculations at the point of sale.

1.4 SmartOps

SmartOps is the proven inventory optimization tool for determining optimal size and location of inventory in end-to-end supply chain for targeted customer service levels (Figure 1).

Figure 1: How SmartOps performs end-to-end optimization



SmartOps is designed to fill critical gaps in the area of supply chain planning. The system generates optimal planning parameters at the item and SKU level to support demand fulfillment, while taking into account the inherent nonlinear, uncertain nature of supply chains.

At the end of 2012, MD&D purchased an enterprise license for SmartOps. The next chapter will explain the background of J&J and OCD and the drivers for purchasing SmartOps.

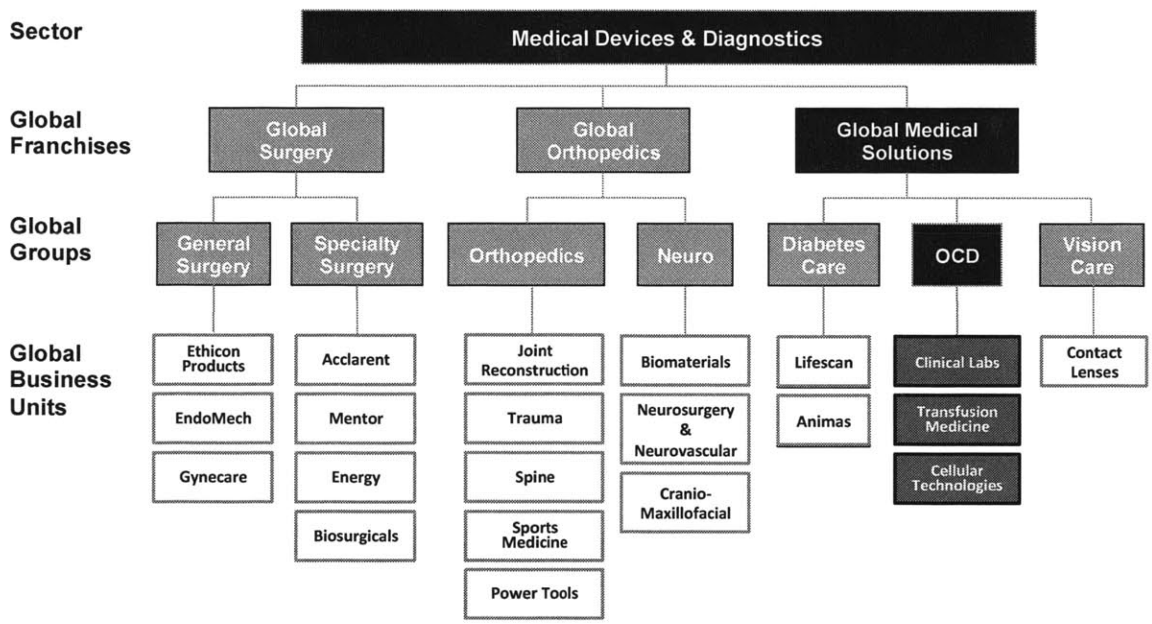
2 Johnson and Johnson

Johnson & Johnson is a broadly diversified healthcare company that operates in three primary sectors: pharmaceuticals, medical devices and diagnostics, and consumer goods.

2.1 Medical Devices and Diagnostics

The MD&D sector encompasses multiple diverse groups that span orthopedics, diabetes care, vision care, cardiovascular care, minimally invasive surgery, diagnostics and more (Figure 2).

Figure 2: Johnson and Johnson MD&D Structure



The internship project in this thesis focused on applying SmartOps' technology to the OCD group within MD&D.

2.2 Ortho Clinical Diagnostics

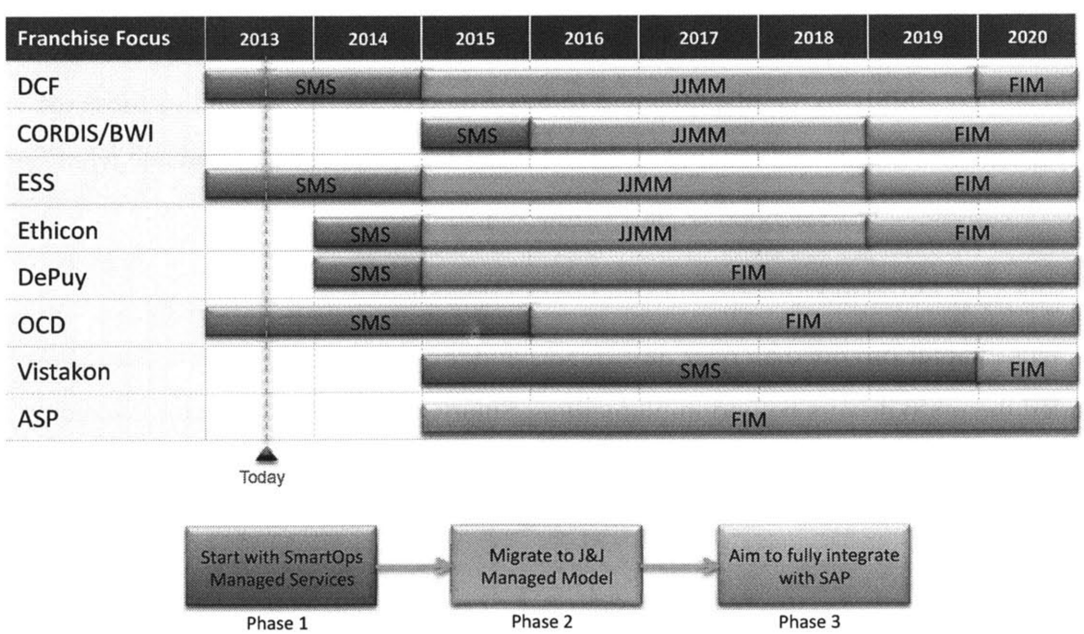
In 1997 two Johnson and Johnson companies merged to form **Ortho Clinical Diagnostics**: 1) Ortho Diagnostic Systems, a worldwide leader in transfusion medicine reagents and instrument systems, and 2) Johnson & Johnson Clinical Diagnostics, a worldwide leader in clinical laboratory systems (Ortho-Clinical Diagnostics, Inc.). Ortho Clinical Diagnostics serves the transfusion medicine community and laboratories around the world. The company provides total solutions for screening, diagnosing, monitoring and confirming diseases early, before they put lives at risk (Ortho-Clinical Diagnostics, Inc.).

Two major business units of OCD are Transfusion Medicine and Clinical Laboratories. Transfusion Medicine includes businesses such as Donor Screening. The Donor Screening business develops instruments and systems to screen blood for AIDS and other diseases. Clinical Laboratories offers patented technologies that are used in testing, for example, toxicology and drug monitoring tests. Next we will discuss the main drivers behind implementing SmartOps in MD&D, specifically within the OCD group.

2.3 Project Objective

As illustrated in Figure 3, the MD&D sector has a seven-year plan for the SmartOps project. The long-term objective is to reduce MD&D inventory by 8.4 days of supply. MD&D will start each group with SmartOps managed services, which means the model is hosted on SmartOps servers. Then MD&D will migrate to a J&J managed solution and the model will be hosted on J&J servers. The final step is for SmartOps to fully integrate with SAP. However, this final step will not come until much later when SAP builds a solution to integrate directly with SmartOps.

Figure 3: SmartOps Strategic Engagement Plan (Macoszek)



As stated before, the project in this thesis focused on applying SmartOps to the OCD group within MD&D. The focus was on two primary business units Transfusion Medicine and Mainframe Slides. There were three main drivers for these businesses to implement SmartOps.

The first driver was to become a more centralized supply chain. Transfusion Medicine and Mainframe Slides had, what we would call, a decentralized supply chain. The global affiliates (nodes closest to the customer) did not make forecasts available to the rest of the supply chain. Instead, each stage of the supply chain estimated mean demand based on orders received from customers, without knowledge of the affiliates' forecast (Simchi-Levi, Kaminsky and Simchi-Levi). A decentralized supply chain in which only the retailer [node closest to the customer] knows the customer demand can lead to significantly higher variability, particularly when lead times are large (Simchi-Levi, Kaminsky and Simchi-Levi).

The second driver was, prior to SmartOps both businesses were planned outside of integrated, system-based processes; for example, using excel spread sheets and historical averages rather than forecasts. The result was large variances from significantly over-running raw material and finish good projections.

Lastly, the supply chain team had a lot of difficulty getting the commercial team to trust their safety stock projections. Therefore, supply chain managers felt SmartOps would add credibility to the planning and forecasting process. As a result of these drivers, OCD's senior management concluded that both the Transfusion Medicine and Mainframe Slides business units were ideal to start a SmartOps pilot.

2.4 Chapter Summary

This chapter provided an overview of J&J and the MD&D sector. In addition, we detailed the main drivers behind implementing SmartOps in the Transfusion Medicine and Mainframe Slides business units. The next chapter will explain more about the inputs and outputs required for a successful run of the SmartOps model.

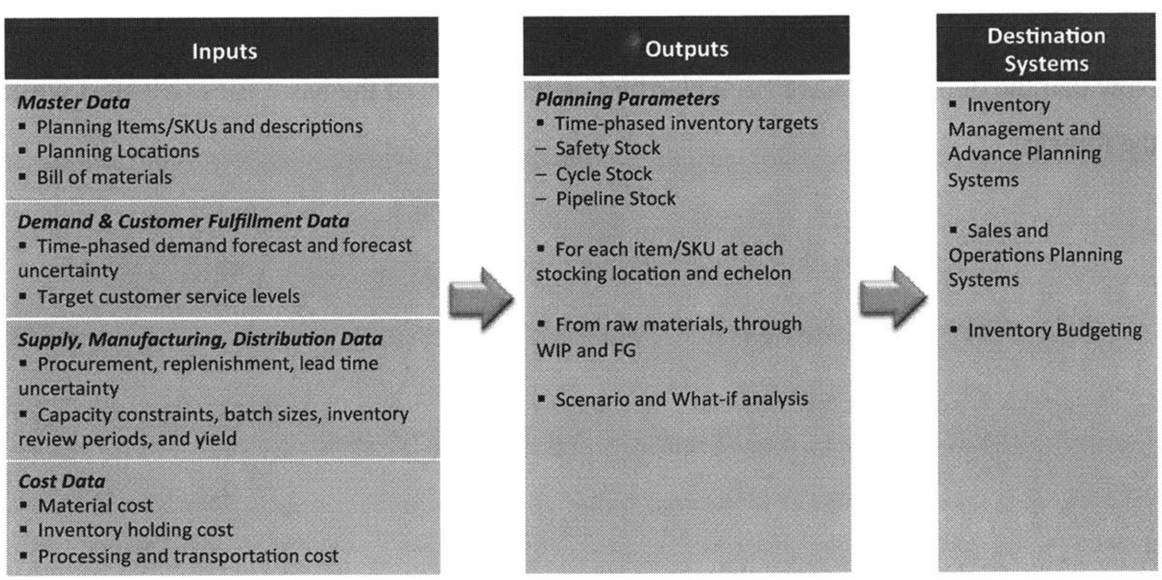
3 SmartOps Inputs and Outputs

Chapter 4 will discuss the process we used to build the SmartOps model with OCD's data. However, before the methodology can be explained, it is important to give a high-level explanation of SmartOps and the inputs required to perform a SmartOps run.

3.1 Integration

As illustrated in Figure 4, SmartOps takes existing supply chain data and planning parameters as input. Inputs include stochastic data - such as demand forecast uncertainty and supply lead time uncertainty, along with service targets, capacity, bills of material, related costs, and other critical information (Macoszek). SmartOps then uses sophisticated algorithms to calculate planning parameters such as safety stock, cycle stock, pipeline stock, and customer service levels. These planning parameters can be used in supply chain planning and inventory planning systems to help achieve inventory reductions and cost savings.

Figure 4: High-level SmartOps Inputs and Outputs (Macoszek)



SmartOps inputs are in the form of data tables. Some of the tables are optional and SmartOps can run without them. But there are six required tables that SmartOps cannot run without: Primary Forecast, Primary Sales, Primary BOM, Primary Sourcing, Master

Data, and Locations.[1] The SmartOps tables are created from basic files, which will be explained first.

3.2 Basic Files

3.2.1 Definitions

A few definitions and descriptions must be explained, before the basic files can be discussed. These definitions will be referenced throughout this thesis:

- **Initial data load** - The first time data tables are loaded into SmartOps for a supply chain project.
- **Table revision** - After the initial data load, SmartOps requires regular updates (revisions) for each data table, on a monthly or bi-weekly basis.
- **Stocking node** – A location (node) in the network that holds inventory.
- All SmartOps tables must contain data for **every** item and location combination in the supply chain network.
- **Weekly buckets** – All forecast and sales data has to be converted into weekly buckets with Monday being the first day of the week.

Now that the definitions have been clarified, a description of the basic files will start with the forecast.

---

[1] For confidentiality reasons the tables have been renamed

3.2.2 Forecast

Figure 5: Example of SmartOps Forecast file (Macoszek)

ITEM_ID	LOCATION_ID	SHIP_TO	REVISION_DATE	PERIOD_DATE	FORECAST_VALUE	SUPPLY_CHAIN_ID
		Default "Customer"	The starting date for the period associated with the forecast data for the specific item.	The date on which the forecast data for the specific item has been updated for the associated period.	The forecast data related to the period for the specific item expressed in terms of volume.	Unique Integer Identifies associated with a Supply Chain
ABC	XXX	Customer	7/1/13	7/1/13	12	1
ABC	XXX	Customer	7/1/13	7/8/13	17	1
ABC	XXX	Customer	7/1/13	7/15/13	13	1
ABC	XXX	Customer	7/1/13	7/22/13	18	1
ABC	XXX	Customer	7/1/13	7/29/13	14	1
ABC	XXX	Customer	7/1/13	8/5/13	19	1
				52 weeks forward		
ABC	XXX	Customer	7/8/13	7/8/13	15	1
ABC	XXX	Customer	7/8/13	7/15/13	20	1
ABC	XXX	Customer	7/8/13	7/22/13	16	1
ABC	XXX	Customer	7/8/13	7/29/13	21	1
ABC	XXX	Customer	7/8/13	8/5/13	17	1
ABC	XXX	Customer	7/8/13	8/12/13	22	1
				52 weeks forward		

As illustrated in Figure 5, for the initial data load the Forecast file must contain at least 52 weeks of forecast history. After the first load, future revisions must have at least 36 weeks of future (forward looking) forecasts. Every item in the supply chain network must have a unique Item ID and there should also be a unique Location ID for each stocking node in the network. Ship To is always defined as Customer for all stocking nodes. Revision Date is the date a particular forecast is revised, or updated. Period Date represents the date of the Forecast Value. Forecast Value is the quantity of the item forecasted. Lastly, Supply Chain ID is a unique number that identifies a specific supply chain that is being modeled in SmartOps. It is important to note that the Revision Date can never be greater than the Period Date.

3.2.3 Sales

The Sales file is very similar to the Forecast file except for one exception, there is a Sales Value. Item ID, Location ID, Ship To, Period Date, and Supply Chain ID have the same meaning as the Forecast file (Figure 6). There is a Sales Value that represents the quantity of item sold for a particular Period Date. This Sales Value should be the date the item is actually sold, not the shipment date.

Figure 6: Example of SmartOps Sales file (Macoszek)

ITEM_ID	LOCATION_ID	SHIP_TO	PERIOD_DATE	SALES_VALUE	SUPPLY_CHAIN_ID
Unique code that identifies item in supply chain.	Unique code that identifies location in supply chain.	Identifies customer-facing destination of item. Default "Customer"	The starting date for the period associated with the historical sales data for the specific item.	The historical sales data related to the period for the specific item.	Unique Integer associated with a Supply Chain
ABC	America	Customer	7/1/13	20	1
ABC	America	Customer	7/8/13	22	1
ABC	America	Customer	7/15/13	20	1
ABC	America	Customer	7/22/13	22	1
ABC	America	Customer	7/29/13	21	1

52 wks or more back

3.2.4 Bill of Materials

As illustrated in Figure 7, the Bill of Materials file contains the amount (Quantity) of each component needed to produce **one unit** of each base item.

Figure 7: Example of SmartOps Bill of Materials file (Macoszek)

LOCATION_ID	BASE_ITEM_ID	COMP_ITEM_ID	QUANTITY	FROM_DATE	TO_DATE
Unique code that identifies the production location of the manufacturing BOM.	Unique code that identifies the finished good of the manufacturing BOM.	Unique code that identifies the raw material of the manufacturing BOM.	The amount of the component item needed to produce ONE UNIT of base	The start date of when this BOM information is active.	The end date of when this BOM information is active.
America	ABCD	A	2	05/06/2012	12/31/1999
America	ABCD	B	1	05/06/2012	12/31/1999
America	ABCD	C	1	05/06/2012	12/31/1999
America	ABCD	D	3	05/06/2012	12/31/1999

Location ID remains unique for each stocking node in the network. Base Item ID is the finished good product ID. So Base Item ID should link to the Item ID field in the both Forecast and Sales tables. Comp Item ID is another unique code that identifies the raw materials for each base item. Quantity is the amount of component needed to product **one unit** of the base item. From Date is the start date that the BOM is active and To Date is the end date that the BOM should be inactive.

3.2.5 Sourcing

The Sourcing file connects two different nodes (distribution centers) in the supply chain network. In addition, if an item is sourced from two different locations the Sourcing file sets up the correct quota between the two locations.

Figure 8: Example of SmartOps Sourcing table (Macoszek)

ITEM_ID	FROM_LOCATION_ID	TO_LOCATION_ID	FROM_DATE	TO_DATE	SOURCING_QUOTA	DURATION	MODE_NAME
Unique code that identifies source item in supply chain.	Unique code that identifies the From/SourceLocation	Unique code that identifies the To/Destination location	The start date of when this sourcing information is active. Format " MM/DD/YYYY"	The end date of when this sourcing information is active. Format " MM/DD/YYYY"	The source item amount needed during the sourcing period.	The lead time in days	Identifies the mode used to transfer the associated item from the source location to the destination location.
ABC	America	Europe	5/6/2012	12/31/1999	1	7	Plane

Item ID, From Date, and To Date contain the same information as the Bill of Materials (Figure 8). From Location ID and To Location ID are unique codes that identify the source and destination locations respectively. Sourcing Quota is the amount of a specific item that is needed during the sourcing period. The Sourcing Quota will automatically default to "1", unless the item is being sourced from multiple locations. If an item is being sourced from multiple locations then Sourcing Quota will be equal to a percentage. For example, if an item is being sourced half from Europe and half from China the following data would be entered in the Sourcing file:

1. Record 1
    a. **Item ID** = ABCD
    b. **From Location** = Europe
    c. **To Location** = USA
    d. **Sourcing Quota** = 0.5
2. Record 2
    a. **Item ID** = ABCD
    b. **From Location** = China
    c. **To Location** = USA
    d. **Sourcing Quota** = 0.5

Duration is the lead time (in weeks) that it takes to get from the source to the destination location. Mode Name is the method used to transfer the item from the source location to the destination location.

3.2.6 Master Data

The Master Data file consists of miscellaneous data that is used to populate the SmartOps tables that will be discussed in Section 3.3. For simplicity and confidentiality, only a few of the fields in the master data file are listed below. However, these fields are representative of the type of data in this file.

Figure 9: Example of Information in Master Data file (Macoszek)

Field Name	Definition
ITEM_ID	Unique code that identifies item in supply chain.
LOCATION_ID	Unique code that identifies location in supply chain.
STOCKING_POINT_TYPE	Identifies a stocking point as either a StockingNode or NonStockingNode
HOLDING_COST_PCT	Cost associated with holding inventory at a stocking location. Expressed as percentage of unit cost. Smartops multiplies them to calculate the holding cost.
MINIMUM_BATCH_SIZE	Lets you set a minimum order quantity that must respected for manufacturing or external ordering.
BATCH_SIZE	The order quantity that is agreed-upon between the upstream and downstream nodes.
PROCESSING_LEAD_TIME	Expressed in number of Periods (period being week for a weekly model). Elapsed time from when the order is placed on an upstream location until that location begins to fill that order. This can include order receipt time, processing time, and queuing time.
PRODUCTION_TIME	Expressed in number of Periods (period being week for a weekly model). Time that it takes from when the upstream (supplier) location begins to fill that order until it is shipped to the downstream location.
TRANSIT_TIME	Expressed in number of Periods (period being week for a weekly model). Time that it takes from when the upstream (supplier) location to physically transport the goods to a downstream location.
PBR	Period between review or replenishment. The amount of time between when planning decision or replenishment can be made.
ITEM_NAME	Text description of the item
ITEM_UOM	The unit of measure that applies to each item.
MAX_SHIP_LIFE	The maximum number of periods an item can remain at a given node before it becomes unusable.

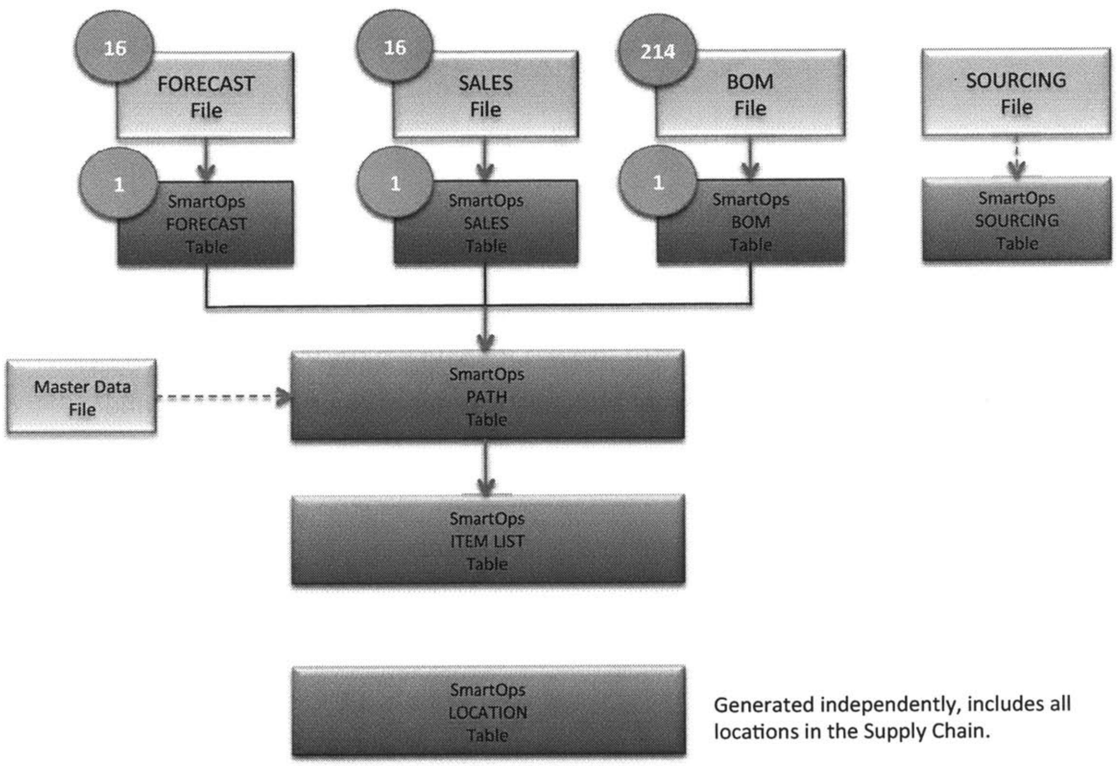
3.2.7 Basic Files Summary

These five basic files (forecast, sales, bill of materials, sourcing, and master data) are building blocks for the SmartOps tables. The next section describes how the basic files are used to create the SmartOps tables.

3.3 Tables

There are six main SmartOps tables: Forecast, Sales, BOM, Path, Item List, and Sourcing. As illustrated in Figure 10, the primary tables are created from the basic files. The ratio could be several basic files to one table depending on the number of item and location combinations. There is also a Location table that is generated independently, which includes all locations in the supply chain.

Figure 10: The SmartOps Table Creation Process



After the tables are created they are fed into the SmartOps model. This creates a successful run (Figure 11).

Figure 11: Successful SmartOps Run

3.4 Chapter Summary

This chapter included a high-level explanation of SmartOps and the inputs required to perform a SmartOps run. Next we will discuss the process for building a SmartOps model specifically for the Ortho Clinical Diagnostics supply chain at Johnson and Johnson.

4 Building the Model

The benefits of SmartOps depend heavily on data quality. In this chapter, we will explain how various data inputs were used to build the SmartOps model for Ortho Clinical diagnostics.

4.1 Scope

There are 1,393 products total in Mainframe Slides and Transfusion medicine. But only 133 Transfusion Medicine and 81 Mainframe slide products were included in this internship project (and thesis). This project was the beginning phase, for the OCD business fully transitioning to using SmartOps for all inventory optimization. Including a small subset of products initially, allows the OCD organization to exhibit better change management over people's behavior, data inputs, and overall IT infrastructure.

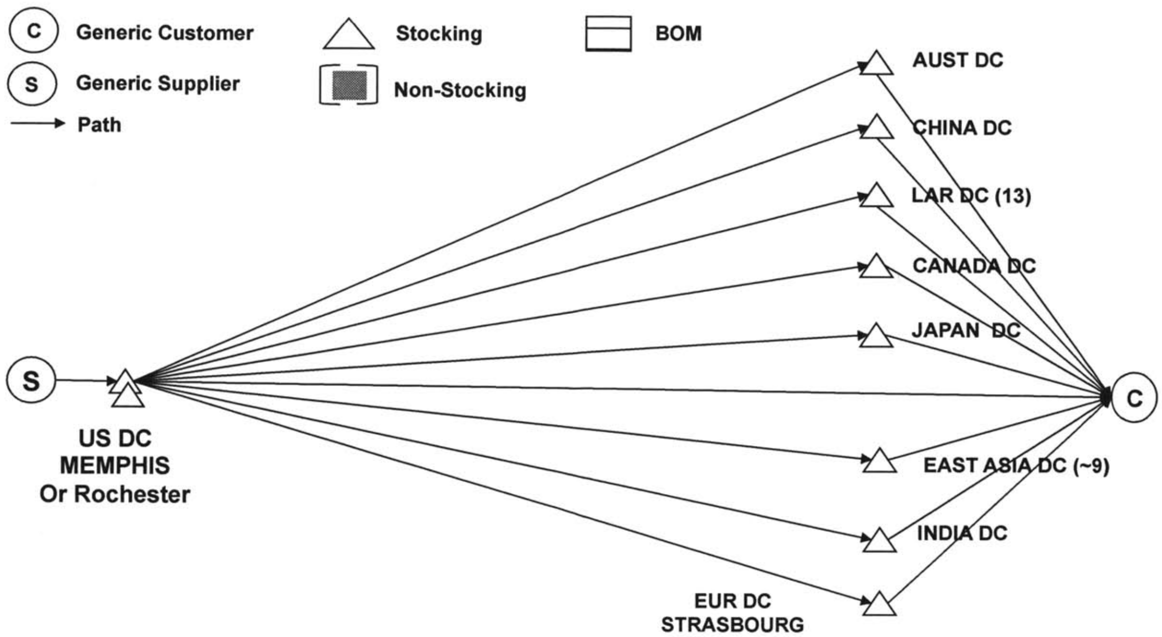
4.2 Model End-to-end Supply Chain

The first step to building the SmartOps model was to model the end-to-end supply chain for both businesses. This exercise was completed with the assistance of SmartOps consultants. We created one model for the Transfusion Medicine supply chain (Figure 12) and another model for the Mainframe Slides supply chain (Figure 13).

4.2.1 Transfusion Medicine

As illustrated in Figure 12, the Transfusion Medicine business sources all of their finished goods from external suppliers. Finished goods include chemicals, machines, equipment, etc. The majority of items are shipped to a central warehouse in Memphis, TN where they are packaged and rebranded as OCD products. A small percentage of finished good products are shipped to Rochester, NY from the suppliers. This small percentage is typically the big capital equipment, such as racks and machines. The core OCD team manufacturing and planning team is located in Rochester, NY. So the team maintains more control over the capital equipment (racks and machines) by having them shipped directly to where the core team is located.

Figure 12: Transfusion Medicine Supply Chain



** ***Stocking*** = *Node holds inventory. This node would have a safety stock value.*

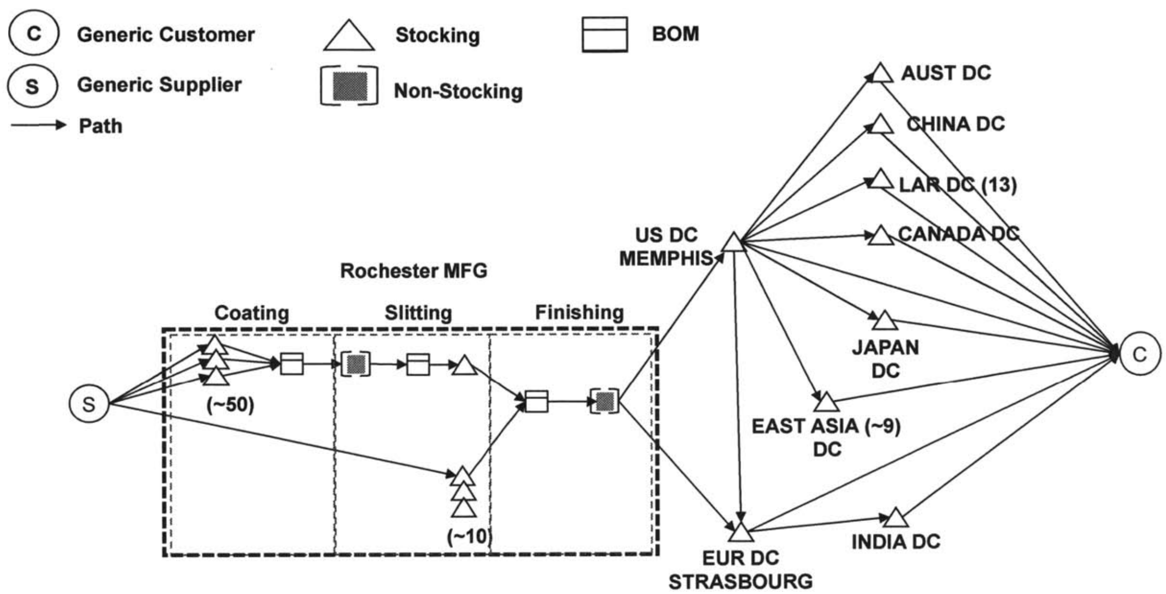
** ***Non-Stocking*** = *Node does not hold inventory. This is more of a "pass through" node.*

From the Memphis warehouse, or Rochester warehouse, items are shipped to affiliate locations around the world. Lastly, products are shipped from the global affiliates to the customer. Suppliers do not ship directly to affiliate nodes because it is not cost effective. Most suppliers do not have the capacity or ability to ship directly to affiliate nodes. Also, consolidation of affiliate orders, and sometimes assembly of machines, is performed in the Memphis warehouse.

4.2.2 Mainframe Slides

As illustrated in Figure 13, the Mainframe Slides business is very similar to Transfusion Medicine in regards to the location of global affiliates and utilization of the Memphis warehouse. However, the Mainframe Slides business actually manufactures finished goods. Raw materials are sent from suppliers to the manufacturing plant in Rochester, NY. The raw materials are converted into finished goods via the coating, slitting, and finishing process. Finished slides are sent either directly to the main warehouse in Memphis, TN or to the Strasbourg affiliate location in Europe. Cost and shelf life is the main driver behind splitting the finished goods between Memphis and Strasbourg.

Figure 13: Mainframe Slides Supply Chain



** ***Stocking*** *= Node holds inventory. This node would have a safety stock value.*

** ***Non-Stocking*** *= Node does not hold inventory. This is more of a "pass through" node.*

** ***BOM*** *= Bill of Materials*

It is cheaper for OCD to ship via ocean rather than using air. However, ocean has a four to five week lead-time, while the lead-time for air is only one week. Finished slides that ship directly to Memphis from Rochester are shipped via air. The majority these slides have a shelf life of 8 – 12 months. It is imperative that the short shelf life items are shipped via air, so they can arrive to the customer before expiring. The remaining finished slides that go to Strasbourg from Rochester are shipped via ocean. Shelf life for these items is greater than 18 months, which is why they can be shipped via ocean. The other nuance in this supply chain is the shipment of slides from Strasbourg to India rather than to India from Rochester. The driver behind this decision is cost savings achieved by shipping from France to India.

Regardless of where the finished slides are received initially, all of the global affiliate locations send product to customers accordingly based on customer orders. Now that we successfully modeled the supply chain for both businesses, the next step was to identify data sources for the SmartOps model.

4.3 Identify Data Sources

At the beginning of this thesis we posed the question, "what are the risks [of inventory optimization vendor technologies] in regards to data quality?" Mapping out data sources at Johnson and Johnson better equipped us to answer this question and come to conclusions of risk exposure as a result of inaccurate or incorrect data.

A detailed description of the data sources we used to create each SmartOps table is located in Appendix 9.1. A snippet of this table is below in Figure 14. As illustrated in Figure 14, some of the data was obtained from SAP's EEC module. But a majority of global affiliates' forecast and sales data was maintained manually in excel spreadsheets. Further complicating the manner, each affiliate had a different spreadsheet format and a different method for calculating the supply chain values.

Figure 14: Fragment of Table with Data Sources for OCD's SmartOps model

Data Table	Field Name	Data Type	Nullable	Data Source
ITEM_LIST	ITEM_ID	VARCHAR2(64)	N	SAP ECC 6
ITEM_LIST	ITEM_NAME	VARCHAR2(256)	N	SAP ECC 6
LOCATION_LIST	LOCATION_ID	VARCHAR2(64)	N	SAP ECC 6
LOCATION_LIST	LOCATION_NAME	VARCHAR2(256)	N	SAP ECC 6
ITEM_LOCATION_PATH	STOCKING_POINT_TYPE	VARCHAR2(64)	N	Excel spreadsheet
ITEM_LOCATION_PATH	INVENTORY_UNIT_COST	NUMBER	N	Standard Costs
ITEM_LOCATION_PATH	BATCH_SIZE	NUMBER	Y	SAP ECC 6
ITEM_LOCATION_PATH	PROCESSING_LEAD_TIME	NUMBER	Y	SAP ECC 6
ITEM_LOCATION_PATH	LEAD_TIME_ERROR	NUMBER	Y	Excel spreadsheet
ITEM_LOCATION_PATH	PBR	INTEGER	N	SAP ECC 6; Manually for affiliate sites
ITEM_LOCATION_PATH	ON_HAND_INVENTORY	NUMBER	Y	SAP ECC 6 and Regional OTCs
ITEM_LOCATION_PATH	FROZEN_WINDOW	NUMBER	Y	SAP ECC 6; Manually for affiliate sites
SOURCING	FROM_LOCATION_ID	VARCHAR2(64)	N	Excel spreadsheets
SOURCING	TO_LOCATION_ID	VARCHAR2(64)	N	Excel spreadsheets

Data Table	Field Name	Data Type	Nullable	Data Source
BOM	LOCATION_ID	VARCHAR2(64)	N	SAP ECC 6
BOM	BASE_ITEM_ID	VARCHAR2(64)	N	SAP ECC 6
BOM	COMP_ITEM_ID	VARCHAR2(64)	N	SAP ECC 6
BOM	QUANTITY	NUMBER	N	SAP ECC 6
FORECAST	REVISION_DATE	DATE	N	Excel spreadsheets from regions
FORECAST	PERIOD_DATE	DATE	N	Excel spreadsheets from regions
FORECAST	FORECAST_VALUE	NUMBER	N	Excel spreadsheets from regions
SALES	PERIOD_DATE	DATE	N	Excel spreadsheets from regions
SALES	SALES_VALUE	NUMBER	N	Excel spreadsheets from regions

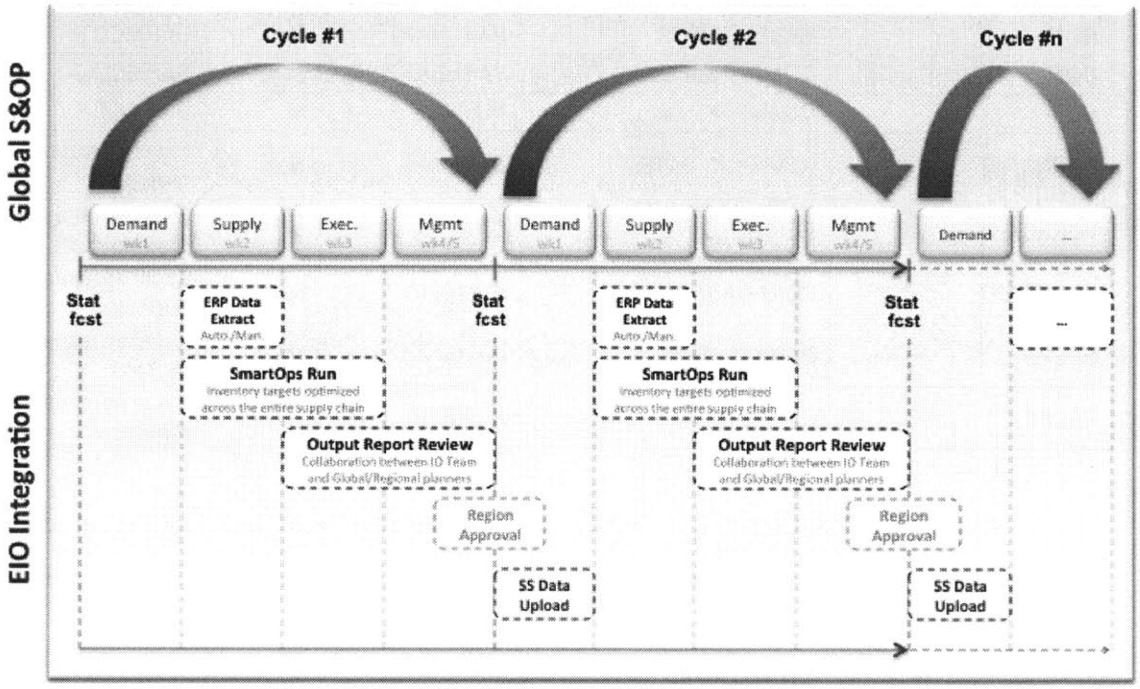
Retrieving data from spreadsheets raised an immediate "red flag" when identifying data sources. This process became even more convoluted when we started the process of actually gathering the data from each global affiliate and inventory analyst.

4.4 Gather Data and Build Inbound Files

OCD elected to run the SmartOps model on a monthly basis.[2] As a result, data had to be gathered from each affiliate node and system on a monthly basis, coinciding directly with the monthly S&OP cycle (Figure 15).

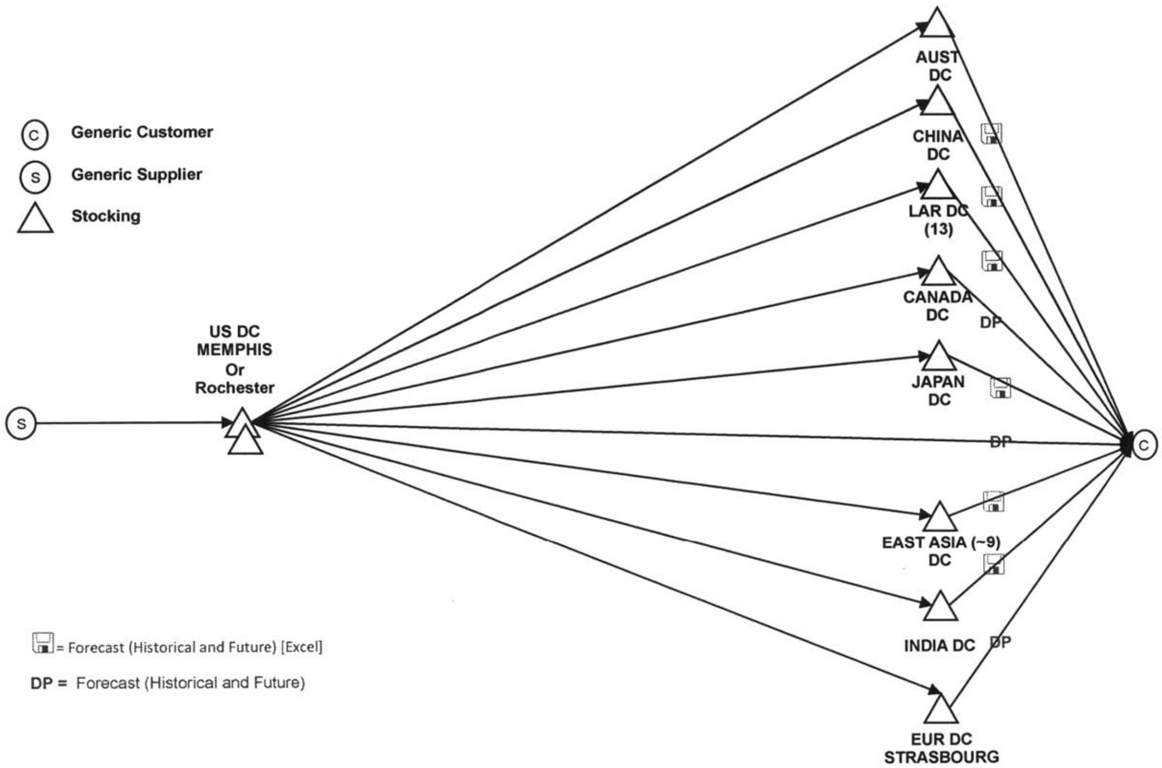
[2] *Please note this decision is the company's discretion. Some enterprises that use SmartOps elect to run the model bi-weekly or weekly.*

Figure 15: SmartOps Process Integrated Into the S&OP Framework (Macoszek)



The process for gathering data and building the inbound files varied widely depending on the affiliate location, file format, and the SmartOps table being created. This was a labor-intensive and manual process. On a monthly basis there are 16+ excel files received from each global affiliate. There are an additional 50+ files for each Bill of Material, and around 20+ files that contain the master data. Each one of these files can contain over 200,000 rows of data. Every file received or pulled from a system has to be validated, “cleansed” and re-formatted. Figure 16 shows an example of the split between data sources for global affiliates in the Transfusion Medicine business. Most of the data was stored and obtained from excel spreadsheets.

Figure 16: Transfusion Medicine Supply Chain Map of Data Sources



The manual process used to validate, "cleanse" and re-format **every** file will not be explained. However, we will discuss the process used for two of the files starting with the Strasbourg Forecasts.

4.4.1 Converting Strasbourg Forecasts

Similar to the other global affiliates, the Strasbourg forecasts are maintained and calculated in spreadsheets. We obtained the sales and forecast files from Strasbourg by asking a dedicated contact (inventory analyst) to upload the files to a central SharePoint location.[3] We then cleansed and re-formatted each file by using the following manual process.

[3] This process was followed on a monthly basis.

Figure 17: Strasbourg Forecasts - Revision Dates and Period Dates

	A	B	C	D	E	F	G	H	I	J	K	L	M
11	Item	Description	Region	WH	Dmd/Fct	2010/09	2010/10	2010/11	2010/12	2011/01	2011/02	2011/03	2011/04
12	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	Sales	144	50	100	137	123	163	119	65
13	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130908								
14	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130811								
15	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130714								
16	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130609								
17	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130512								
18	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130414								
19	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130310								
20	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130210								
21	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20130113								
22	1037274	A		SXB	20121209								
23	1037274	A		SXB	20121111								
24	1037274	A		SXB	20121014								
25	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20120909								
26	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20120812								
27	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20120715								
28	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20120610								
29	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20120513								
30	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20120415								

Revision dates

Period dates

** ***Revision Date*** = *the date a particular forecast is revised, or updated.*

** ***Period Date*** = *the date of the Forecast Value*

** ***Forecast Value*** = *the quantity of the item forecasted.*

The Strasbourg forecast file is received from the analyst in the format illustrated in Figure 17. Revision Dates are in columns (vertical) and Period Dates are in rows (horizontal). The only Revision Dates needed are the dates for the current month. Therefore all dates prior to the current month are deleted. For example, if the current month is November 2013, any Revision Date rows prior to November 2013 are deleted (October 2013, Sept 2013, etc. are deleted).

Figure 18: Strasbourg Forecasts - Revision Dates prior to November 2013 deleted

	A	B	C	D	E	F	G	H
1	QUANTIT					2010/09	2010/10	2010/11
2	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
3	1053180	ALKP/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
4	1202670	AMYLASE/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
5	1307164	THEOPHYLLINE/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
6	1314343	SALICYLATE/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
7	1336544	TRIGLYCERIDES/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
8	1450261	CALCIUM/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
9	147692	FAME DISP SYRINGE SET 12x8	Europe	SXB	20131110 | FC			
10	148473	OSP WASH/DISPENSE VERIFCN KIT	Europe	SXB	20131110 | FC			
11	148482	FAME REAGENT CONTAINER SET/48	Europe	SXB	20131110 | FC			
12	1513209	PHOSPHORUS/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
13	1515808	IRON/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
14	1612365	BUBC/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
15	1632660	LITHIUM/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
16	1655281	ALT/5 PACK/250 SLDS	Europe	SXB	20131110 | FC			
17	1668409	LIPASE/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
18	1669829	CHOLESTEROL/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
19	1707801	GLUCOSE/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
20	1721869	AMMONIA/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
21	1726926	AMMONIA/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
22	182703	REAGENT CONTAINER IT-12 PCS	Europe	SXB	20131110 | FC			
23	1914605	CHOLINESTERASE/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
24	1921204	MAGNESIUM/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
25	1924547	IRON/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
26	1926740	CRP/5 PACK/250 SLDS	Europe	SXB	20131110 | FC			
27	1943927	URIC ACID/5 PACK/300 SLDS	Europe	SXB	20131110 | FC			
28	1988211	ALBUMIN/5 PACK/90 SLDS	Europe	SXB	20131110 | FC			
29	235400	Hamilton Summit Tips 504x20pkg	Europe	SXB	20131110 | FC			
30	235904	Ortho Verseia Tips 1000 UL	Europe	SXB	20131110 | FC			
31	4056	LINER ASSEMBLY BIOVUE	Europe	SXB	20131110 | FC			
32	559879	Avioq HTLV Wash Bufr 500ml WW	Europe	SXB	20131110 | FC			

In the example illustrated in Figure 18, current month is November 2013; so all Revision Dates prior to November 2013 have been deleted. The same logic applies to Period dates (Figure 19). We only need to keep Period Dates for the current month up to two years out. Therefore everything prior to this month is deleted. For example, if the current month is November 2013, any Period Date columns prior to November 2013 are deleted (October 2013, Sept 2013, etc.).

Figure 19: Strasbourg Forecasts - Period dates prior to November 2013 deleted

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Item Numb	Description				2013/11	2013/12	2014/01	2014/02	2014/03	2014/04	2014/05	2014/06
2	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	20131110 | FC	117	155	115	99	111	74	86	116
3	1053180	ALKP/5 PACK/300 SLDS	Europe	SXB	20131110 | FC	3,055	3,500	2,836	2,545	3,470	2,373	2,732	4,184
4	1202670	AMYLASE/5 PACK/300 SLDS	Europe	SXB	20131110 | FC	592	758	711	674	765	711	631	724
5	1307164	THEOPHYLLINE/5 PACK/90 S	Europe	SXB	20131110 | FC	55	80	45	65	61	55	50	81
6	1314343	SALICYLATE/5 PACK/90 SLDS	Europe	SXB	20131110 | FC	63	119	36	62	65	83	49	88
7	1336544	TRIGLYCERIDES/5 PACK/300	Europe	SXB	20131110 | FC	2,372	3,147	2,264	2,311	2,648	2,125	2,381	2,992
8	1450261	CALCIUM/5 PACK/300 SLDS	Europe	SXB	20131110 | FC	2,766	3,911	2,752	2,664	2,819	2,382	2,736	3,111
9	147692	FAME DISP SYRINGE SET 12	Europe	SXB	20131110 | FC	17	9	12	7	11	10	9	13
10	148473	OSP WASH/DISPENSE VERIF	Europe	SXB	20131110 | FC	3	7	4	3	6	7	4	8
11	148482	FAME REAGENT CONTAINER	Europe	SXB	20131110 | FC	10	8	15	11	13	11	15	11
12	1513209	PHOSPHORUS/5 PACK/300 S	Europe	SXB	20131110 | FC	1,195	1,502	1,265	1,105	1,478	1,132	957	1,818
13	1515808	IRON/5 PACK/300 SLDS	Europe	SXB	20131110 | FC	767	1,152	1,069	967	935	983	645	1,092
14	1612365	BUBC/5 PACK/90 SLDS	Europe	SXB	20131110 | FC	523	644	570	754	859	614	501	770
15	1632660	LITHIUM/5 PACK/90 SLDS	Europe	SXB	20131110 | FC	184	279	191	199	270	193	161	250
16	1655281	ALT/5 PACK/250 SLDS	Europe	SXB	20131110 | FC	5,378	6,970	5,882	4,990	6,589	4,858	3,715	8,271
17	1668409	LIPASE/5 PACK/300 SLDS	Europe	SXB	20131110 | FC	473	538	496	470	522	448	422	643

SAP ECC works on a monthly cycle and all data is stored monthly. So the affiliates in Mainframe Slides and Transfusion Medicine also store their data in monthly buckets. However, SmartOps requires all data to be processed in weekly buckets. Therefore, the next step is to convert Period and Revision Dates into weekly buckets. To convert Period Dates, we manually inserted columns for all of the weekly Period Dates. Then we divided the original amount by 4 (or 5 depending on the month), and copied the formula down in each respective column (Figure 20). After converting all of the dates the file looks similar to Figure 21 with each Item Number, Location, and Forecast Value in weekly format.

Figure 20: Strasbourg Forecasts - Manual Conversion of Monthly Data to Weekly Data

F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
2013/11	2013/12	2014/01	2014/02	2014/03	2014/04	2014/05	2014/06	2014/07	2014/08	2014/09	2014/10	2014/11	2014/12	2015/01	20:
117	155	115	99	111	74	86	116	64	57	98	86	119	156	146	
3,055	3,500	2,836	2,545	3,470	2,373	2,732	4,184	2,508	1,898	3,249	2,582	3,220	3,659	3,690	
592	758	711	674	765	711	631	724	720	442	704	620	619	781	916	
55	80	45	65	61	55	50	81	45	44	50	60	62	83	63	
63	119	36	62	65	83	49	88	34	32	82	56	61	115	47	
2,372	3,147	2,264	2,311	2,648	2,125	2,381	2,992	2,242	1,479	2,356	2,136	2,429	3,169	2,857	
2,766	3,911	2,752	2,664	2,819	2,382	2,736	3,111	2,761	2,209	2,923	2,479	2,936	4,194	3,638	

AD	AE	AF	AG
11/4/2013	11/11/2013	11/18/2013	11/25/2013
29.25	29.25	29.25	29.25
763.75	763.75	763.75	763.75
148	148	148	148
13.75	13.75	13.75	13.75
15.75	15.75	15.75	15.75
593	593	593	593
691.5	691.5	691.5	691.5

Figure 21: Strasbourg Forecasts – All Data in Weekly Format

	A	B	C	D	E	F	G	H	I
1	Item Numb					11/4/2013	11/11/2013	11/18/2013	11/25/2013
2	1037274	ACET/5 PACK/90 SLDS	Europe	SXB	11/04/2013	29.25	29.25	29.25	29.25
3	1053180	ALKP/5 PACK/300 SLDS	Europe	SXB	11/04/2013	763.75	763.75	763.75	763.75
4	1202670	AMYLASE/5 PACK/300 SLDS	Europe	SXB	11/04/2013	148	148	148	148
5	1307164	THEOPHYLLINE/5 PACK/90 S	Europe	SXB	11/04/2013	13.75	13.75	13.75	13.75
6	1314343	SALICYLATE/5 PACK/90 SLD	Europe	SXB	11/04/2013	15.75	15.75	15.75	15.75
7	1336544	TRIGLYCERIDES/5 PACK/30C	Europe	SXB	11/04/2013	593	593	593	593
8	1450261	CALCIUM/5 PACK/300 SLDS	Europe	SXB	11/04/2013	691.5	691.5	691.5	691.5
9	147692	FAME DISP SYRINGE SET 12	Europe	SXB	11/04/2013	4.25	4.25	4.25	4.25
10	148473	OSP WASH/DISPENSE VERIF	Europe	SXB	11/04/2013	0.75	0.75	0.75	0.75
11	148482	FAME REAGENT CONTAINER	Europe	SXB	11/04/2013	2.5	2.5	2.5	2.5
12	1513209	PHOSPHORUS/5 PACK/300 S	Europe	SXB	11/04/2013	298.75	298.75	298.75	298.75
13	1515808	IRON/5 PACK/300 SLDS	Europe	SXB	11/04/2013	191.75	191.75	191.75	191.75
14	1612365	BUBC/5 PACK/90 SLDS	Europe	SXB	11/04/2013	130.75	130.75	130.75	130.75
15	1632660	LITHIUM/5 PACK/90 SLDS	Europe	SXB	11/04/2013	46	46	46	46
16	1655281	ALT/5 PACK/250 SLDS	Europe	SXB	11/04/2013	1344.5	1344.5	1344.5	1344.5
17	1668409	LIPASE/5 PACK/300 SLDS	Europe	SXB	11/04/2013	118.25	118.25	118.25	118.25

After several more manual steps, including data validation and accuracy checks, the Strasbourg forecast file is converted into the SmartOps format (Figure 22). The SmartOps format includes very specific field headings such as, ITEM_ID, LOCATION_ID, SHIP_TO, etc. This file, combined with the forecast files all other global affiliate locations, is used to create the Forecast Table. The process of converting files to tables will be explained more in section 4.5.

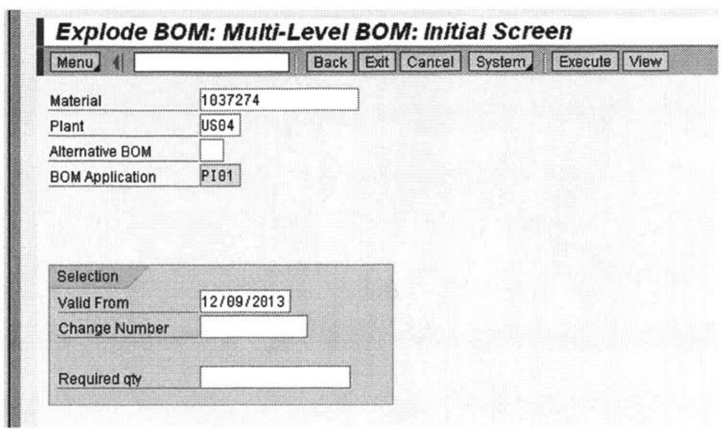
Figure 22: Strasbourg forecast – SmartOps inbound file

SUPPLY_CHAIN_ID	ITEM_ID	LOCATION_ID	SHIP_TO	REVISION_DATE	PERIOD_DATE	FORECAST_VALUE
3	1037274	SXB	Customer	11/11/13	11/11/13	29.25
3	1037274	SXB	Customer	11/11/13	11/18/13	29.25
3	1037274	SXB	Customer	11/11/13	11/25/13	31
3	1037274	SXB	Customer	11/18/13	11/18/13	29.25
3	1037274	SXB	Customer	11/18/13	11/25/13	31
3	1037274	SXB	Customer	11/25/13	11/25/13	33

4.4.2 Bill of Materials from Crossroads SAP

Bill of Material files, for the Mainframe Slide items manufactured in Rochester, were pulled from Crossroads SAP. Similar to the Forecast files, the process to convert Bill of Materials was followed on a monthly basis. First, we complied the list of finished good material numbers (made in the plant) with manufacturing BOMs.

Figure 23: Multi-level BOM Screen in Crossroads SAP



Item-by-item we entered the following information into the multi-level BOM screen in Crossroads SAP (Figure 23).

a. Fill in "**Material Number"** field.
b. Fill in "**Plant**" field
c. Fill in "**BOM Application**" field; It is usually **PI01**
d. Hit **Execute**

We then exported the file to save as an excel spreadsheet. This process was repeated item-by-item for all finish good codes (81 codes).

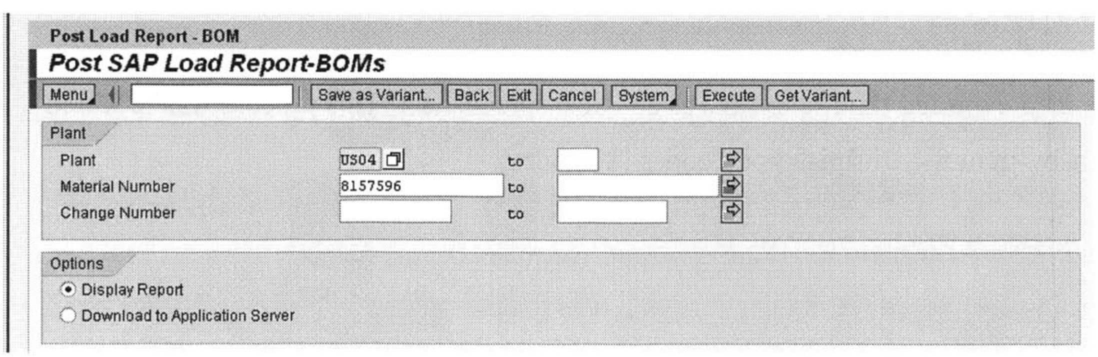
Figure 24: Excel Output from Multi-level BOM Report in Crossroads SAP

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	12/09/2013			Dynamic List Display				1							
2															
3	########				Display Multilevel BOM										
4															
5	Material					1037274									
6	Plant/Usage/Alt.					US04 / 1 / 01									
7	Description					ACET/5 PACK/90 SLDS									
8	Base Qty (PK)					1									
9	Reqd Qty (PK)					1									
10															
11															
12		Level no.		Item	Object ID		Object de	Qty (CUn	Un	Ict	SLoc	SupplyAre	MTyp	Valid fron	Valid to
13															
14		0.1		10	J14669		M-LOT 29/	5	EA	L			HALB		########
15		..2		10	J06016		CHEM 29A	10.35	DM	L			HALB		########
16		...3		10	29ACET---		ACETAMIN	0.399	DM	L			HALB		########
17		4		10	M1358		SPR	2.729	GR	L			HALB		########
18		5		10	D1333		SPR	1	GAI	L			HALB		########
19		6		10	ACETONE02		ACETONE,	1.174	GR	L			ROH		########
20		6		20	R1314		CELLULOSI	0.128	GR	L			ROH		########
21		6		30	R1323		HOMBITAI	0.874	GR	L			ROH		########
22		5		20	ACETONE02		ACETONE,	1.71	GR	L			ROH		########
23		5		30	MEK03		METHYL ET	0.478	GR	L			ROH		########
24		5		40	D554		SRF	0.073	GR	L			HALB		########
25		6		10	ACETONE02		ACETONE,	0.047	GR	L			ROH		########
26		6		20	R107		TRITON X-	0.027	GR	L			ROH		########

1037274_cs12

The excel output from Crossroads' multi-level BOM report contains a field titled, "Object Id" (Figure 24). This field contains all of the components that make up a specific finished good item. We used these component codes as an input to the Post SAP Load BOM report in Crossroads (Figure 25).

Figure 25: Post SAP Load BOM screen in Crossroads SAP



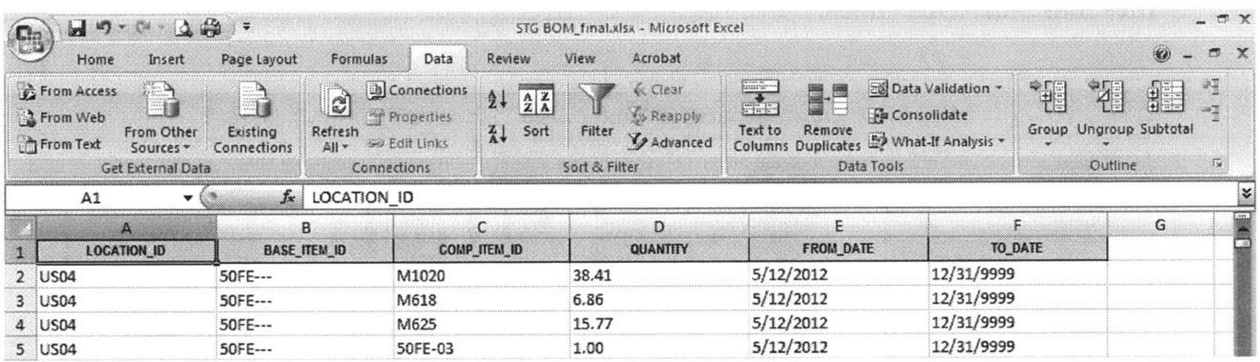
For each finished good item we entered the following information into the Post Load BOM screen.

a. **Manufacturing Plant**

b. Copied entire list "Object Id" codes from the Multi-level BOM excel file and enter into **Material Number** field
c. Hit execute
d. Save to excel

This generated a BOM that contained a base item ID and the quantity of each component needed to make one unit of this base item. However, this file required more processing (more than 20 additional steps) of cleansing and re-formatting to be converted to the SmartOps format. An example of the final result is displayed in Figure 26, a BOM ready for the SmartOps model.

Figure 26: BOM File in SmartOps Format



	A	B	C	D	E	F	G
1	LOCATION_ID	BASE_ITEM_ID	COMP_ITEM_ID	QUANTITY	FROM_DATE	TO_DATE	
2	US04	50FE---	M1020	38.41	5/12/2012	12/31/9999	
3	US04	50FE---	M618	6.86	5/12/2012	12/31/9999	
4	US04	50FE---	M625	15.77	5/12/2012	12/31/9999	
5	US04	50FE---	50FE-03	1.00	5/12/2012	12/31/9999	

4.4.3 Automation

As stated before, the process for gathering data and building the inbound files was a manual and time consuming process. However, we were able to automate some of the process by creating macros. A macro was created to convert the dates from monthly to weekly format. This saved 15 minutes on average for each forecast. In addition, we created a macro to convert the Bill of Material files to the SmartOps format this saved over three hours of manual work each month. Using macros to automate the process helped tactically to make the process faster and more efficient. But building the inbound files requires a more strategic and standardized solution. This will be discussed in later chapters.

4.4.4 Section Summary

For simplicity reasons, we did not review the manual process used to convert every file. However, the two processes to convert the Sales and Bill of Materials demonstrate the effort required to gather data and build the inbound files. We were able to automate some parts of the process, but most of the process remains manual. Chapter 0 will include specific recommendations on how to improve this process moving forward.

4.5 Create Tables

The final step in building the model is to use the five basic files (forecast, sales, bill of materials, sourcing, and master data) to build the SmartOps tables. For confidentiality reasons, the specific details of this process cannot be explained. However, the figures below demonstrate a high-level representation of the steps we used to convert raw data files into SmartOps tables.

Figure 27: Create SmartOps Tables Step 1 – Convert Files (Macoszek)

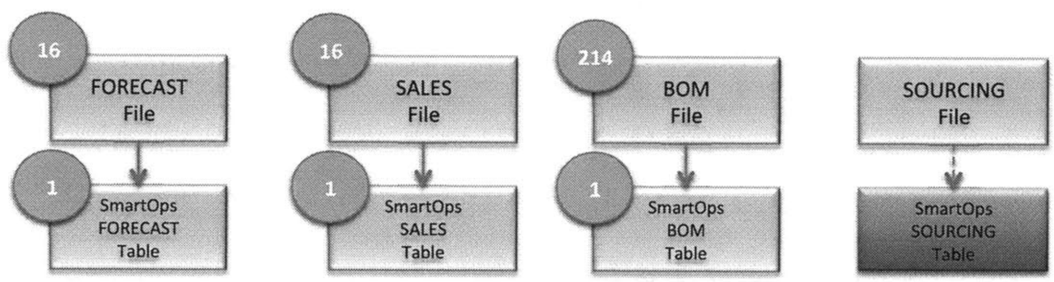


Figure 28: Create SmartOps Tables Step 2 – Combine Tables (Macoszek)

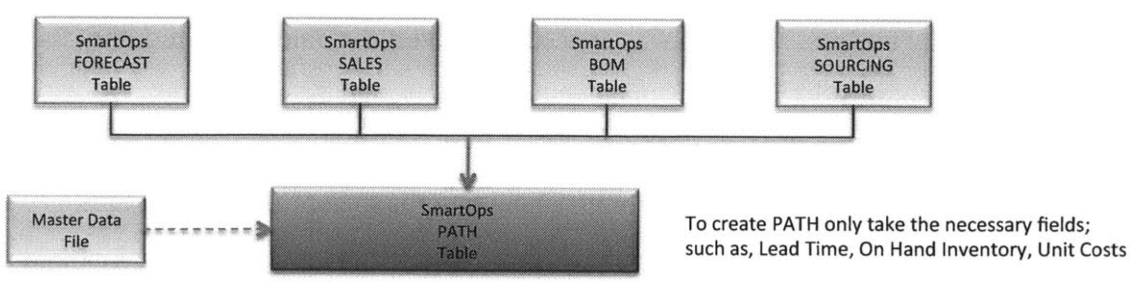
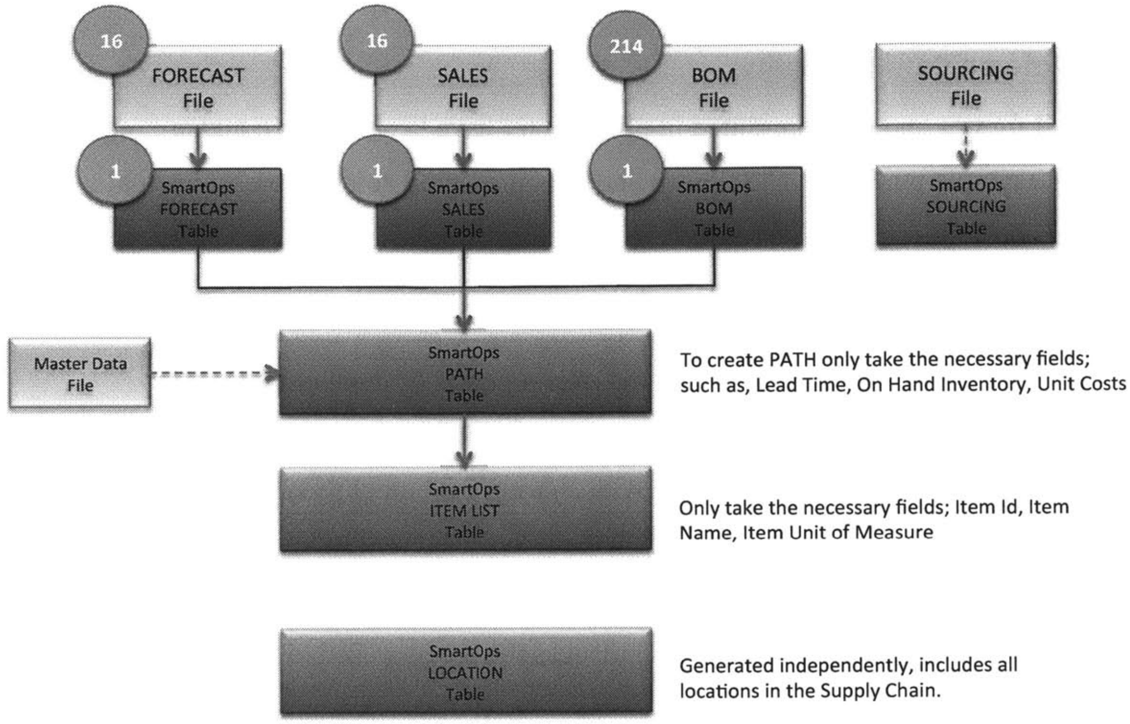


Figure 29: Create SmartOps Tables Step 3 – Generate Item List and Create Location Table (Macoszek)



4.6 Chapter Summary

In this chapter we discussed the experience building the model for Johnson and Johnson. We also explored the question, "what are the risks [of inventory optimization vendor technologies] in regards to data quality?" As demonstrated, there is a high-risk exposure as a result of inaccurate or incorrect data. And data cleansing is very important to the process. The next chapter will reveal the results we derived from running the SmartOps model.

5 Results and Analysis

5.1 Note on Confidentiality

All figures and data presented in this chapter have been changed and are provided only for example purposes. The figures and data presented do not represent actual Johnson and Johnson data.

5.2 Model Validation

Validating was a continuous process over a period of three months. We implemented small refinements after every run to continue and improve the output. After several revisions, we were comfortable with sharing the output report to a larger audience and having the supply chain analysts implement the suggested safety stock values.

This thesis will not include the detailed process and methods we used to validate all of the model's output. However, we will discuss the process used to validate the safety stock values and lead-time.

5.2.1 Safety Stock

After our first successful run, we met with supply chain analysts (subject matter experts) in both Transfusion Medicine and Mainframe Slides to analyze the results. The objective was to: 1) explain to the SMEs how SmartOps calculates safety stock, cycle stock, and pipeline stock, 2) describe how SmartOps calculations differed from their current process, and 3) analyze the output for a few high selling items to validate if the suggested values "made sense." Based on the output of our first run, SMEs were able to immediately spot discrepancies in the data.

Mainframe Slide SMEs were concerned that SmartOps suggested high safety stock values in the EMEA region. The SmartOps values suggested for EMEA, were about four times, or a 3000% increase, from the current numbers. We performed root cause analysis and learned the issue was attributed to raw data discrepancies. One of the raw data files sent from India affiliates contained incorrect unit of measure conversions. As a result, the raw forecast numbers for several products were 4x's the accurate values. We worked with our India contact to correct the unit of measure error and produced new tables for SmartOps, which solved the discrepancy.

Other adjustments that were made as a result of safety stock inaccuracies included: 1) Reconverting monthly forecast files into weekly format after finding human errors in calculation conversions, 2) Removing sales values in SmartOps tables for products with duplicate data, 3) Changing nodes in the network from "stocking" to "non-stocking" if inventory was not held in that location, and 4) updating the sourcing table with information to correctly link two nodes together in the network.

5.2.2 Lead Time Variability

Lead-time variability was another area that required data validation. In our first run of the model, we did not utilize the "Lead Time Error" field located in the SmartOps Path table. However, we noticed (by looking at safety stock values) that SmartOps was always assuming an on time delivery from upstream nodes (both suppliers and affiliate nodes). On time delivery is rare in OCD due to the temperamental nature of raw materials and finished goods. Therefor, SmartOps assuming on time delivery was not a true representation of OCD's business.

To resolve this issue, we worked with SMEs to define low, medium, and high variability as one week, 1.5 weeks, and 2 weeks respectively. We designated this variability in the "Lead Time Error" field for all items coming from the supplier into Rochester and/or Memphis. We also applied this same logic to products going from the Rochester plant to Memphis and from Rochester plant to Strasbourg.

Over the course of several weeks, we performed several other validation checks similar to the safety stock and lead-time validations. The objective was to ensure the output contained quality data. We eventually arrived at a stage where we were comfortable with sharing the results with a larger audience.

5.3 Model Results

Figure 30: SmartOps model results

Product Line	Region	Current Safety Stock	Smart Ops Safety Stock	Current Cycle Stock	SmartOps Cycle Stock	Current On Hand	Smart Ops On Hand	Delta	% Delta
ExOps TM	AsiaPac	-	200	-	50	-	300	300	
	Canada	200	90	50	150	250	230	(20)	-8%
	EMEA	11,000	3,500	2,000	4,000	13,000	8,000	(5,000)	-38%
	Latam	-	-	-	-	-	-	-	
	US	26,000	600	11,000	28,000	37,000	28,000	(9,000)	-24%
ExOps TM Total (excluding AsiaPac and LATAM)		37,200	4,190	13,050	32,150	50,250	36,230	(14,020)	-28%
MF Slides	AsiaPac	-	196,000	-	29,000	-	225,000	225,000	
	Canada	9,000	5,000	2,500	5,000	11,500	10,000	(1,500)	-13%
	EMEA	93,000	64,000	16,000	26,000	109,000	90,000	(19,000)	-17%
	Latam	-	22,000	-	16,000	-	38,000	38,000	
	US	248,000	108,000	109,000	97,000	357,000	205,000	(152,000)	-43%
MF Slides Total (excluding AsiaPac and LATAM)		350,000	177,000	127,500	128,000	477,500	305,000	(172,500)	-36%

** *AsiaPac and LATAM were excluded from the totals because current inventory levels were not obtained from these regions.*

As expected, the SmartOps model recommended safety stock values much lower than OCD's current safety stock levels (Figure 30). Recommendations for total inventory on hand decreased by ~14k and ~172k for Transfusion Medicine and Mainframe slides respectively. The total percentage decrease recommended for both businesses was an astounding 64%. This global view of inventory reductions provides a big-picture window into SmartOps recommended inventory levels. However, focusing on specific products also reveals some interesting patterns and helps rationalize the output.

Figure 31: SmartOps output, Mainframe Slides Item 10mf

Product Line	Item ID	Region	Current Safety Stock	Smart Ops Safety Stock	Current Cycle Stock	SmartOps Cycle Stock	Current On Hand	Smart Ops On Hand	Delta	% Delta	Delta $$
MF Slides	10mf	AsiaPac	-	9,000	-	1,100	-	10,200			$ -
MF Slides	10mf	Canada	150	150	50	100	200	250	50	25%	$ 650
MF Slides	10mf	EMEA	2,500	1,700	230	700	2,730	2,300	(430)	-16%	$ (5,590)
MF Slides	10mf	LATAM	-	500	-	400	-	950	-		$ -
MF Slides	10mf	US	11,000	5,200	4,000	4,300	15,000	9,500	(5,500)	-37%	$ (71,500)
		Total	13,650	7,050	4,280	5,100	17,930	12,050	(5,880)	-33%	$ (76,440)

** *AsiaPac and LATAM excluded from the totals because current inventory levels was not obtained*

10mf is a Mainframe Slide item and **10tm** is a Transfusion Medicine item. These two products are considered high volume and high selling items for both businesses. SmartOps recommended a 33% decrease of total on hand inventory for **10mf (**Figure 31**).**

But in Canada the inventory increased by 25%. In current state, Canada contained the least amount of inventory compared to all other global regions. However, because of lead-time, service level, and cost inputs, SmartOps optimized **10mf** to hold more inventory in Canada and less inventory everywhere else. By making adjustments to just this one item Mainframe Slides could gain inventory cost savings of ~$76,000.

Figure 32: SmartOps output, Transfusion Medicine Item 10tm

Product Line	Item ID	Region	Current Safety Stock	Smart Ops Safety Stock	Current Cycle Stock	SmartOps Cycle Stock	Current On Hand	Smart Ops On Hand	Delta	% Delta	Delta $$
Transfusion Medicine	10tm	AsiaPac	-	240	-	40	-	300			$ -
Transfusion Medicine	10tm	EMEA	11,000	3,700	1,900	4,000	13,000	8,000	(5,000)	-38%	$ (7,500)
Transfusion Medicine	10tm	US	14,500	-	5,800	19,000	21,000	18,500	(2,500)	-12%	$ (3,750)
		Total	25,500	3,700	7,700	23,000	34,000	26,500	(7,500)	-22%	$ (11,250)

*** AsiaPac excluded from the totals because current inventory levels was not obtained*

*** 10tm is not sold in LATAM or Canada*

SmartOps recommended a 22% decrease of total on hand inventory for **10tm** (Figure 32**).** An interesting observation is that the system recommended zero safety stock for the US affiliate, but almost 5,800 units of cycle stock. Simultaneously there is a 3,700 safety stock recommendation for EMEA. In a nutshell, SmartOps is effectively recommending moving safety stock closer to the customer. SmartOps also does not want Transfusion Medicine to hold any inventory at the node that receives immediate shipment from suppliers (which is the US affiliate). This was a common theme in the Transfusion Medicine output. By making adjustments to **10tm** Transfusion Medicine could gain inventory cost savings of ~$11,250.

Both Figure 33 and Figure 34 illustrate a comparison of current state safety stock inventory versus SmartOps recommended safety stock, in units and in dollars respectively. These figures are meant for illustrative purposes only. Therefore, they only contain the European items for Mainframe Slides products. Overall, the Smartops recommendations are a substantial decrease from OCD's current state, which saves the business a large amount of money.

Figure 33: Current State Inventory vs SmartOps Recommendations (In units) - Mainframe Slide products in EMEA Region

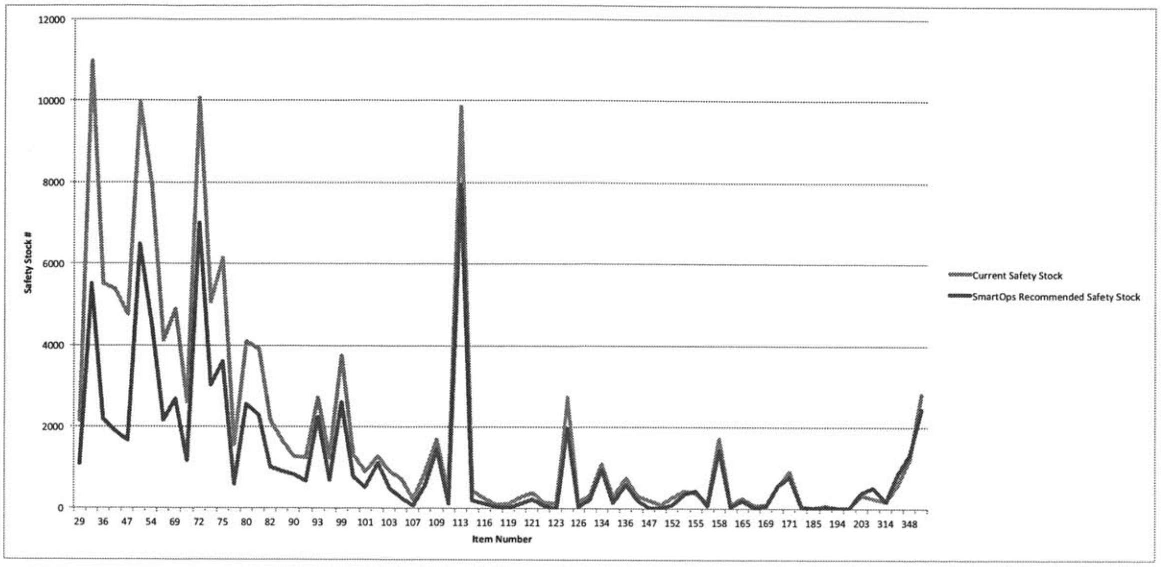
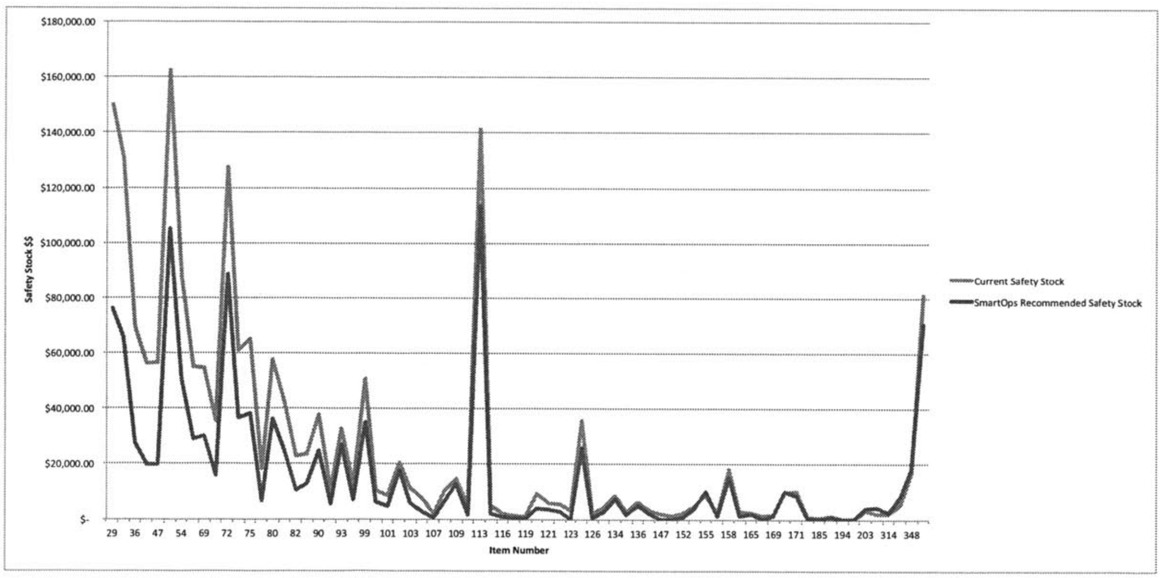


Figure 34: Current State Inventory vs SmartOps Recommendations (in dollars) - Mainframe Slide products in EMEA Region



5.4 Chapter Summary

In this chapter we discussed our process for validating the SmartOps output. Validation was a continuous process in which we implemented small refinements over a period of months. Each iteration helped us improve the output until we finally arrived at the point where the numbers "made sense." The output results suggested significant reductions to current safety stock inventory levels. And by drilling down to the item level we were able to uncover some other characteristics of the output.

The output successfully demonstrated one of the key benefits of using a multi-echelon inventory optimization tool. Optimizing inventory closer to the customer was a common theme in the Transfusion Medicine output. In the current state, OCD calculated safety stock at each individual node based only on that specific nodes inventory characteristics. By using SmartOps and looking at the supply chain from a global perspective, OCD is able to make smarter decisions, such as optimizing the inventory closer to the customer.

6 Implementation

Implementation is an ongoing process. OCD will continue refining the method for implementation as time goes on. Two necessary steps to implementation are, 1) getting an agreement from manufacturing and supply chain analysts to review and integrate the new safety stock targets, and 2) developing SmartOps competency within the OCD group.

6.1 Manufacturing Leads and Inventory Analysts

Manufacturing Leads, Inventory Analysts, and Supply Chain Planners will be the individuals who input the SmartOps recommended values into OCD's planning systems. Therefore, working cross-functionally with global affiliates in each team on a plan for implementation was critical to success. First, OCD's senior management team wanted to increase user convince with SmartOps. The goal was to gain "quick wins" first and show good results. As a result, managers felt the organization would be less resistant, to implementing larger and more drastic SmartOps inventory reductions in the future.

For "quick wins" we suggested concentrating on the products with a plus or minus thirty percent delta between the current on hand inventory and SmartOps suggested on hand inventory. For example, for one of product current on hand inventory was 33,000 units. SmartOps recommended only 26,000 units for this product. This is a 21% percent change so this product was a good "quick win" candidate. But OCD could not just "flip a switch" and change their production schedule from 33,000 to 26,000 units. This is too risky. So we suggested a piece-wise approach to implementing the SmartOps recommended values (Figure 35).

Figure 35: Approach to implementing SmartOps Values

Current SS	SmartOps SS	Current CS	SmartOps CS	Current PS	SmartOps PS	Current On Hand	SmartOps On Hand	Delta On Hand	% Change	New Recommend SS Level	Delta - Current SS vs Recommended	Unit Change
25,000	3,700	7,800	22,300	200	-	33,000	26,000	(7,000)	-21%	21,500	-14%	(3,500)

*** SS = safety stock, CS = cycle stock, PS = pipeline stock*

The delta between the SmartOps on hand and the current on hand is 7,000 units. Half of this delta is 3,500. The current safety stock inventory for this same product was

25,000. Subtracting 3,500 from the current safety stock inventory of 25,000 equals 21,500. A safety stock of 21,500 was the value we recommended the supply chain planners put into the planning systems first. This was a 14% decrease from the current safety stock value. When we received the next monthly output, we would repeat the same process for our "quick win" products until the total on hand inventory targets were hit:

1. Take the delta between SmartOps on hand and current on hand
2. Subtract 1/2 of the on hand delta from the current safety stock inventory value
3. This is the new safety stock target
4. Enter this safety stock target into the planning systems

The stakeholders were on board with this strategy, however they preferred to prioritize the "quick wins" by dollar reductions and not percent decrease of on hand inventory. Dollar reductions are more closely correlated to end-of-the year performance objectives. For confidentiality reasons, we will not disclose the dollar reductions. However, we came to an agreement with the stakeholders that prioritization by dollars was the best approach. The last step was to obtain a synchronization agreement across regions, so that no region loads or executes against the new targets until a "green light" is given from senior managers globally.

6.2 Developing SmartOps Competency

The second step to implementation is developing competency inside the OCD group. As illustrated in Figure 36, SmartOps competency can be developed internally if firms focus on developing the skills of three key people planners/analyst, subject matter experts, and inventory optimization business leads. These users require different levels of knowledge and if they all work in parallel a firm can successfully run a SmartOps model on a monthly basis.

Figure 36: Skill requirement for SmartOps Users (Macoszek)

IO Business Leads	Overall business & Inventory Optimization Process Leads with advanced multistage inventory optimization applications expertise and its algorithms. ▪ Coordinates business involvement, strategic deployment and activities related to SmartOps runs, training material, supply chain modeling, user acceptance, and business process changes. ▪ Monitor, coordinate and directly support the SmartOps jobs & processes, what if scenarios and the inventory targets analysis with individual IO subject matter experts. ▪ Provide the lead, strategy and solution for best practices in inventory optimization.
Level 1. Subject Matter Experts	Users with advanced expertise in supply chain planning processes and master data control. Subject matter expert will support modeling, design, validation, and inventory optimization roll outs. Subject matter experts need to understand: ▪ how to navigate and use the SmartOps Production Environment, create & compare the what if scenarios and analyze the time-varying outputs, ▪ how to navigate and use SQL Oracle database, running the database scripts, manually release the job, and maintain the STG tables, ▪ the SmartOps inputs and outputs, and implications of parameter changes and its impact to ROP/SS calculation, ▪ how to read and analyze the SmartOps reports and provide the recommendations or highlight the poteeential issues. **Skills required:** Expert in Supply Chain/Logistic; strong leadership, ownership and accountability; knowledge in statistics; technical and system experience; system and database knowledge; initiative and creativity.
Level 2. Planners/Inventory Analysts	The users need to understand: ▪ the basic of multistage inventory & planning optimization, ▪ how to use SmartOps reports and analyze the time-varying outputs within their supply chain, ▪ how to navigate in SmartOps Production Environment (view access only), ▪ the implications of parameters changes and its impact on ROP/SS calculation, **Skills required:** Supply Chain/Logistic knowledge; ownership and accountability; basic quantitative knowledge; initiative and creativity.

6.3 Chapter Summary

In this chapter we described the two necessary steps to a successful SmartOps implementation, which are, 1) getting an agreement from inventory analysts and supply chain planners to review and integrate the new safety stock targets, and 2) developing SmartOps competency inside the OCD group. In the next chapter, we will conclude this thesis and provide some recommendations for next steps.

7 Conclusions

In conclusion, senior executives should strongly consider investing in multi-echelon inventory optimization technology. This technology enables supply chains to make better tactical decisions. It is challenging to design and operate a supply chain so that total system wide costs are minimized and system wide service levels are maintained (Simchi-Levi, Kaminsky and Simchi-Levi). By utilizing multi-echelon inventory technology firms can accomplish this objective.

The basis for this thesis was an internship project that focused on implementing SmartOps in the Transfusion Medicine and Mainframe Slides businesses within OCD. The three main drivers for OCD to implement SmartOps were: 1) to become a more centralized supply chain, 2) stop businesses from being planned outside of integrated system-based processes, and 3) getting the commercial team to trust supply chain values. But the OCD business was a decentralized supply chain, which leads to risk when deploying multi-echelon inventory technology.

Supply chains that are decentralized experience higher risks of inaccurate or incorrect data when preparing basic forecast, sales, master data, and bill of materials files for SmartOps. As a result, data cleansing is very important to the process. In addition, decentralized firms typically take longer to implement multi-echelon inventory technology, but they are still able to realize significant inventory reductions. The SmartOps model recommended safety stock values much lower than OCD's current safety stock levels. Recommendations for total inventory on hand decreased by ~14k and ~172k for Transfusion Medicine and Mainframe slides respectively. The total percentage decrease recommended for both businesses was an astounding 64%.

Getting an agreement from stakeholders and developing the firm's knowledge internally is key to a successful implementation of multi-echelon inventory optimization technology. Stakeholder buy-in allows firms to take advantage of benefits larger than inventory reductions. Having information about inventory levels across the entire supply chain enables everyone in the organization to improve the way the supply chain is managed. As a result, firms have a holistic solution to reducing inventory including an overall change of employee behavior.

7.1 Next Steps

As stated before, the MD&D sector has a seven-year plan for the SmartOps project. The long-term objective is to reduce MD&D inventory by 8.4 days of supply. Only a subset of products was selected for this internship project, so this was just the initial phase for OCD. Therefore, next steps include implementing SmartOps throughout the rest of OCD and the remainder of products in the Transfusion Medicine and Mainframe Slides businesses.

In addition, building the inbound files requires a more strategic and standardized solution. SmartOps was recently acquired by SAP. Therefore, long term the entire process will be integrated front to back. However, short term OCD should first coordinate and centralize their forecasting process. Secondly, the group should build an access database to create the basic files and the SmartOps tables. Automating this part of the process would decrease the time spent manually building the SmartOps model and would also help J&J obtain results much faster.

Lastly, we asked the question at the beginning of this thesis, "can companies develop the specialized skillsets to learn inventory modeling in SmartOps or any other vendor technology?" As we demonstrated in Section 6.2, the answer is yes. If firms focus on developing the skills planners/analyst, subject matter experts, and inventory optimization business leads, they can successfully run a SmartOps model on a monthly basis. MD&D should continue and focus on people development as they implement SmartOps throughout the rest of the group.

IT investment decisions are challenging. However, by following some of the processes and steps in this thesis, firms can successfully implement multi-echelon vendor technologies within their organizations. Users of this technology can make tradeoffs based on information from the entire supply chain, which results in a more powerful supply chain strategy and stronger competitive advantage.

8 Bibliography

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9 Appendices

9.1 Data sources for SmartOps tables

Data Table	Field Name	Data Type	Nullable	Data Source
ITEM LIST	ITEM_ID	VARCHAR2(64)	N	SAP ECC 6
ITEM LIST	ITEM_NAME	VARCHAR2(256)	N	SAP ECC 6
ITEM LIST	ITEM_UOM	VARCHAR2(256)	N	SAP ECC 6
LOCATION LIST	LOCATION_ID	VARCHAR2(64)	N	SAP ECC 6
LOCATION LIST	LOCATION_NAME	VARCHAR2(256)	N	SAP ECC 6
PATH	STOCKING_POINT_TYPE	VARCHAR2(64)	N	Excel spreadsheet
PATH	HOLDING_COST_PCT	NUMBER	N	0.1; for now
PATH	INVENTORY_UNIT_COST	NUMBER	N	Standard Costs
PATH	SERVICE_LEVEL	NUMBER	Y	0.5
PATH	MINIMUM_BATCH_SIZE	NUMBER	Y	SAP ECC 6; 1 for everywhere
PATH	BATCH_SIZE	NUMBER	Y	SAP ECC 6
PATH	PROCESSING_LEAD_TIME	NUMBER	Y	SAP ECC 6
PATH	PRODUCTION_TIME	NUMBER	Y	SAP ECC 6
PATH	TRANSIT_TIME	NUMBER	Y	SAP ECC 6
PATH	GRP_TIME	NUMBER	Y	SAP ECC 6
PATH	LEAD_TIME_ERROR	NUMBER	Y	Excel spreadsheet
PATH	COVERAGE_DURATION	NUMBER	Y	13
PATH	PBR	INTEGER	N	SAP ECC 6; Manually for affiliate sites
PATH	ON_HAND_INVENTORY	NUMBER	Y	SAP ECC 6 and Regional OTCs
PATH	INV_ALLOC_POLICY	VARCHAR2(32)	N	Priority
PATH	FROZEN_WINDOW	NUMBER	Y	SAP ECC 6; Manually for affiliate sites
PATH	MAX_SHIP_LIFE	NUMBER	Y	SAP ECC 6
SOURCING	ITEM_ID	VARCHAR2(64)	N	Excel spreadsheets
SOURCING	FROM_LOCATION_ID	VARCHAR2(64)	N	Excel spreadsheets
SOURCING	TO_LOCATION_ID	VARCHAR2(64)	N	Excel spreadsheets
SOURCING	FROM_DATE	DATE	N	1/1/00
SOURCING	TO_DATE	DATE	N	9/9/99

Data Table	Field Name	Data Type	Nullable	Data Source
SOURCING	SOURCING_QUOTA	NUMBER	N	1
SOURCING	DURATION	NUMBER	Y	Excel spreadsheets, value should be in 7 day weeks
BOM	LOCATION_ID	VARCHAR2(64)	N	SAP ECC 6
BOM	BASE_ITEM_ID	VARCHAR2(64)	N	SAP ECC 6
BOM	COMP_ITEM_ID	VARCHAR2(64)	N	SAP ECC 6
BOM	QUANTITY	NUMBER	N	SAP ECC 6
BOM	FROM_DATE	DATE	N	SAP ECC 6
BOM	TO_DATE	DATE	N	SAP ECC 6
FORECAST	SUPPLY_CHAIN_ID	NUMBER	N	3
FORECAST	ITEM_ID	VARCHAR2(64)	N	Excel spreadsheets from regions
FORECAST	LOCATION_ID	VARCHAR2(64)	N	Excel spreadsheets from regions
FORECAST	SHIP_TO	VARCHAR2(256)	N	Generic "Customer" everywhere
FORECAST	REVISION_DATE	DATE	N	Excel spreadsheets from regions
FORECAST	PERIOD_DATE	DATE	N	Excel spreadsheets from regions
FORECAST	FORECAST_VALUE	NUMBER	N	Excel spreadsheets from regions
SALES	SUPPLY_CHAIN_ID	Integer	N	3
SALES	ITEM_ID	VARCHAR2(64)	N	Excel spreadsheets from regions
SALES	LOCATION_ID	VARCHAR2(64)	N	Excel spreadsheets from regions
SALES	SHIP_TO	VARCHAR2(256)	N	Excel spreadsheets from regions
SALES	PERIOD_DATE	DATE	N	Excel spreadsheets from regions
SALES	SALES_VALUE	NUMBER	N	Excel spreadsheets from regions