

IMPROVING FORECAST ACCURACY AND USE

by
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B.S. Manufacturing Engineering, Brigham Young University 1998

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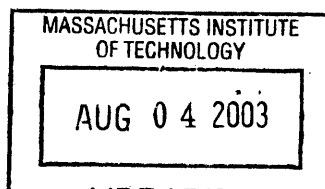
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ABSTRACT

The QWBS division of QUALCOMM produces and sells mobile communications solutions to the transportation industry. In the past few years monthly product sales forecasting has become more complex due to changes in the markets and the economy. A concern has grown about the forecasting process and its output causing performance to be less than optimal. This project was focused on improving the end-to-end forecasting business process by designing and implementing a new paradigm to enhance the forecast creation and better utilize the forecast data.

The process had several issues. One was inconsistent use of tools already in place. The expectation of a perfect forecast and perfect tools when current methods were not adequate was another. In other areas the process did not meet the needs of the next user. Next, the forecast accuracy was low. Complicating this, inadequate communication and mistrust led to word of mouth, expediting and scrambling being used to get things done. Finally, there was no linkage between the forecast and inventory safety stock levels.

This project recommended eight major changes to remedy the situation. Three recommendations enhanced forecast creation. First, establish guidelines for the use of the CRM software used for forecasting. Second, combine the forward-looking customer information from the sales organization with a statistical forecast based on history. Finally, forecast components, rather than entire systems, to take advantage of the risk-pooling concept. Three recommendations enhanced the use of forecasts as well. First, measure the forecast error at the component level. Then set safety stocks based on the error metrics. Third, base finished goods levels on customer demand using an automated implementation of the base-stock model. To improve communication it was recommended that a process for revising the forecast and a process for dealing with unexpected demand on short notice be defined. Implementation of these changes was expected to enhance the creation and use of monthly forecasts and the communication within the organization. The expected results were a more accurate forecast, tools to utilize the forecast more effectively and a process to deal with the surprises that always occur.

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Finally, I want to dedicate this work to my mother, M. Dianne Sampson. Her spirit and optimism throughout her seven-year fight with breast cancer are an inspiration to me.

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1 INTRODUCTION

When someone says the word “forecast” several things come to mind, the foremost being the first rule of forecasts – “they are always wrong”.¹ Yet in today’s manufacturing environment, where component lead times are much longer than the lead-time customers demand, forecasts are a necessary evil. A few complaints about forecasts are “It’s just a guess”, or “It’s going to be wrong, so why should I use it?” Many times those who need forecasts think they can forecast better. They discard or modify what they get from others. These are common problems encountered many times in many settings.

But the question remains, how do you alleviate these problems within an organization? When forecasting is necessary, how do you improve the situation? In some cases you want to minimize the need for the forecast, done by shortening lead times or holding inventory. Other situations call for improving the accuracy of the forecast, through better information or statistical methods. Still other cases call for improving the usage of forecasts, through a variety of methods. On a six-month Leaders for Manufacturing internship in the QWBS division of Qualcomm, Inc., during the second half of 2002, this question was addressed.

The forecasting process at QWBS as defined here is how forecasts are created and how forecasts are used for the monthly time frame. Forecast creation, a team effort of the sales organization and the forecasting department, is based on the subjective assignment of the probability of a sale. The output is massaged, prepared and sent to manufacturing. To use the forecast, manufacturing sends the forecast to the suppliers.

The forecasting process had several issues. One of the issues was inconsistent use of tools already in place, such as use of the customer relationship management (CRM) software used for forecasting. Another was the expectation of a perfect forecast and perfect tools. This was compounded by the fact that the current methods did not work well for all customers. In other areas the process did not meet the needs of the next user, for example, the forecast sent to manufacturing. Next, the forecast accuracy was low. Complicating this, issues of inadequate communication and mistrust led to other problems. As a result, word of mouth, combined with lots of expediting and scrambling, was used to get things done. Finally, there was no linkage between the forecast and inventory safety stock levels.

The goal of this project was to improve upon this situation by initiating eight major changes. Implementation of these recommendations was expected to improve the creation and use of

monthly forecasts and communication within the organization. To improve forecast creation, it was recommended that guidelines be established for the use of the CRM software, the sales organization's forecast be combined with a statistical forecast and components, rather than entire systems, be forecast. To improve the use of forecasts, it was recommended that error be measured at the component level, safety stocks be set based on the error and finished goods levels be based on customer demand. To improve communication, it was recommended that the forecast be revised only when demand will fall outside the forecast error range and joint business decisions be made when dealing with surprises. These changes are expected to result in a more accurate forecast, supply manufacturing with the tools to utilize the forecast more effectively, and provide the organization with a process to deal with the surprises that always occur.

This thesis details the forecasting process as it was at QWBS starting in June of 2002, the problems with the process, the proposed solution, and how the change was accomplished. Chapter 2 describes the existing process for creating and using forecasts and the problems associated with it. Chapter 3 introduces an improved forecasting process and its expected benefits. Chapter 4 covers the leadership aspects of how the changes were instituted. Chapter 5 offers some suggestions for further improvements. Yet before delving into the details, some background on the company, its products, and the drive for the project is helpful for understanding the environment.

1.1 Company Background

Qualcomm, Inc. was founded in 1985 and is “best known as the company that pioneered Code Division Multiple Access (CDMA) technology, which is now used in wireless networks and handsets all over the world.”² The first product to use this CDMA technology was the OmniTRACS system introduced in 1988, which serves the long-haul trucking and other transportation related markets. Today, Qualcomm has grown to approximately 6000 employees and has many more products, the majority focused on serving the personal mobile communications (a.k.a. cell phones) market.

While the other divisions of Qualcomm are mainly focused on serving the mobile phone market, the Qualcomm Wireless Business Solutions (QWBS) division still manufactures and sells mobile communications solutions to the transportation industry where it has “over 460,000 QUALCOMM mobile systems shipped to businesses in more than 39 countries on four

continents.”² Within the transportation industry, there are several market segments, including: the truckload market, long-haul carriers that haul full truckloads; the less-than-truckload market, carriers that haul smaller loads over shorter distances; and private fleets, companies that have their own trucks but whose primary business is not trucking (i.e. Frito-Lay). QWBS is the dominant player in the truckload market with 34 of the top 35 fleets using its products. QWBS started to focus sales efforts in the private fleet and less-than-truckload markets several years after 1988. There is still significant room to grow in these areas. QWBS has several product and service offerings that are sold in all of these markets. While the bulk of sales come within the United States, a significant amount of sales are international.

1.2 Product Background

During this internship QWBS was selling two main types of systems, the OmniTRACS and the OmniExpress product offerings. The “OmniTRACS system is a satellite-based mobile communications and tracking system that provides real-time messaging and position reporting between fleets and their operations centers. Messages are sent via satellite through QUALCOMM’s Network Management Center to dispatch centers throughout the United States. The OmniTRACS system is an interactive, fully integrated information management system that includes two-way mobile communications, satellite tracking and fleet management software.”³ A diagram of the OmniTRACS system, showing its major parts, is shown in Figure 1 below.

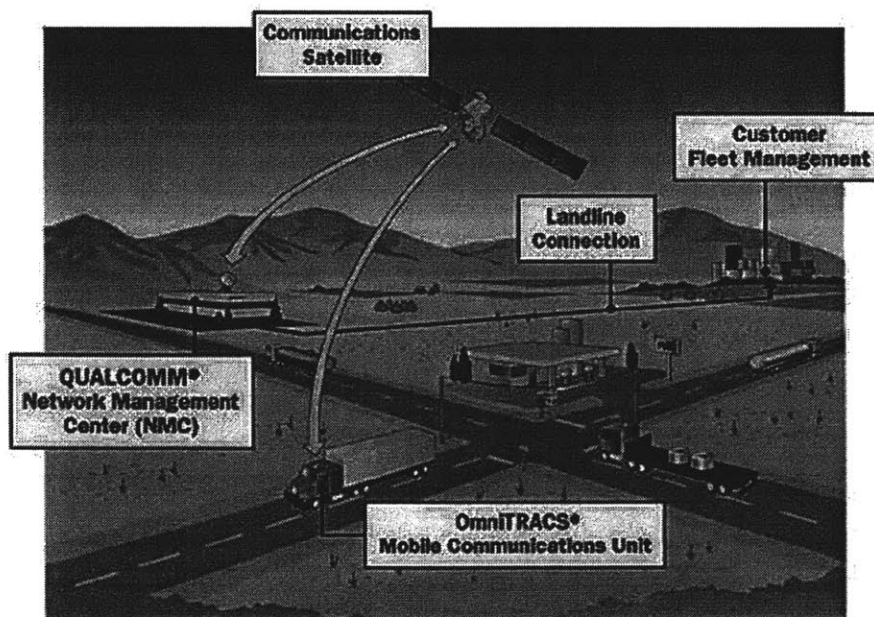


Figure 1 – OmniTRACS System Overview

The OmniExpress has the same basic functionality as the OmniTRACS. It uses CDMA-based digital wireless communications networks instead of satellite networks.

OmniTRACS Components

There are many different permutations of the components for these systems based on when the system was sold, whether or not it was sold to the international market, etc. For simplicity in description and portrayal of the analysis, this paper focuses on the domestic markets and the OmniTRACS system in particular. An OmniTRACS system consists of a satellite modem, a display and cabling connecting it together. There are a few types of each of these components. The satellite modem is the first major component and is formally known as an Antenna Communication Unit or ACU. Domestically, the ACU can come with or without a global positioning system (GPS) option. The ACU is installed outside the cab of the truck. The display is the next major component and is used inside the cab of the truck for driver interaction with the system. There are three types of displays – the display unit (DU), the enhanced display unit (EDU) and the MVPc in vehicle computer. The cabling, the third major component, connects the ACU to the truck's power and the display. There are different cables for each display type, with several lengths available. A complete system is called a master pack and includes an ACU, display and cables. A picture of an ACU with an EDU and MVPc is shown in Figure 2 below.

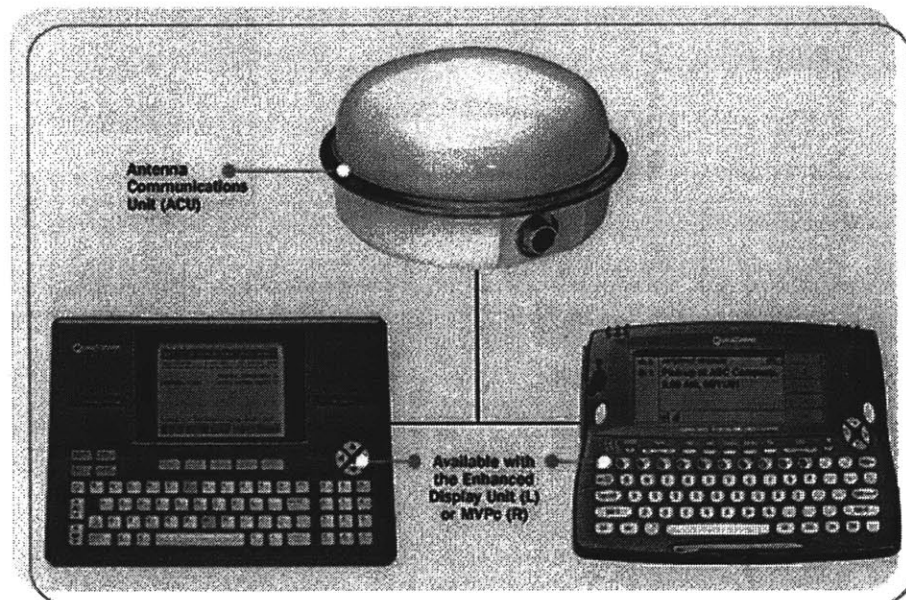


Figure 2 – OmniTRACS Hardware

1.3 Project Background

Several factors motivated this project. The first was the economic and business climate. In the past few years, forecasting of these systems has become more difficult as the business and the markets have changed. Among the factors causing the changes, two stand out: planned expansion into other markets and the recession that started in the year 2000. Prolonged differences between forecasted and actual results caused concern about the forecasting process and the use of its output. As a result, many 'sub-processes' developed, creating 'gaps' in the information flow, and causing different areas to execute on different 'plans'. Another motivation for the project was management's vision of raising the importance of forecasting within the organization and an opportunity to move in that direction with new personnel filling the roles.

The factors behind the motivation for the project combined to create an aspiration to improve the forecasting process. There was agreement change was needed; yet there was no agreement on the shape of the changes. The goal of this project was to provide the organization with a shared vision of the future state of forecasting within QWBS.

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2 EXISTING FORECASTING PROCESS

The forecasting process at QWBS spans several departments and functions within the division. Information flows from the customers to the sales organization to the forecasting department to manufacturing. This section describes the process, as it was when the internship started in June of 2002. To aid the reader, an existing forecasting process flowchart is shown in Figure 5 after the process description.

2.1 Tasks within the Sales Organization

Within QWBS, the sales organization is the direct link to the customer. All QWBS looks to the sales organization for forecasting information. Through interactions with customers the sales people gather and input information into a software package. The customer information is then used to generate a monthly number for the forecast. This section focuses on the tasks of the forecasting process performed entirely within the sales organization.

2.1.1 Interacting with Customers

The sales process starts and ends with customers, the majority being long-haul trucking companies. Because the customers are so central to the process, some characterization of what they are like is needed. According to several sales people, these companies generally don't have a lot of visibility into their future requirements. In general, the customers don't know what they want until they need it. These facts contribute greatly to the difficulty the sales organization has forecasting demand.

It is also important to describe the level of service QWBS provides its customers. The majority of orders are shipped within one business day of receipt. Recently, this practice was changed to allow three days for shipment of larger orders. QWBS considers this high service level an important competitive advantage and wants to maintain it. This fact raises the importance of having an accurate forecast.

2.1.2 Entering Information into the CRM Software

After interacting with customers, the sales people input the information into a customer relationship management (CRM) software package. The critical information used for forecasting is the probability that a potential order will ship that month along with the type and number of

systems. Assigning probabilities has proven to be difficult for the sales people due to the nature of their customers. When asked how they assign the probability of shipment that month, one salesman responded, “I take a swag at it!” In essence, the ‘gut feel’ of the account manager or a guess is used to assign shipment probabilities. Updating the software is ideally done as soon as new information is available but is typically done during weekly conference calls with management. Every week the information from the software is used to create a monthly forecast. This is covered in more detail in the following section. The forecast number becomes the sales organization’s target for that month.

2.2 Tasks within the Forecasting Department

Once customer data has been input into the software, something must be done to translate it into a usable form for the manufacturing organization. These next tasks in the forecasting process are mainly done in the forecasting department. First, market segment forecasts are created. Next, these forecasts are combined and broken down into master packs. The consolidated forecast is then sent on to the manufacturing organization. This section focuses on the details of these tasks.

2.2.1 Creating Market Segment Forecasts

A market segment forecast is the total number of systems or master packs of any type that are projected to sell that month. These forecasts are created the first week of the month as part of the weekly conference call for the forecast team for each market segment. The forecast team consists of the sales managers for the corresponding market segment and the forecast analyst from the forecasting department. The end result of this task is based on customer data input by sales into the CRM software combined with some historical data. The major steps each team uses to create its forecast follow below:

- The data from the CRM software for the current month is exported into an Excel spreadsheet.
- Any potential order with a shipment probability less than 50% is deleted.
- The data is sorted by market segment and by shipment probability.
- The data is grouped into 5 shipment probability buckets (99%-90%, 89%-80%, ... 59%-50%).
- The quantities in the probability buckets are summed to get a total unit quantity for each.

- These total unit quantities are multiplied by a weighting factor corresponding to each probability bucket (the weighting factor is the percentage that historically ships from that probability bucket).
- The weighted quantities are summed.
- The summed quantity is added to a historically derived number of systems that ship weekly but were “un-forecasted” or not in the CRM software.
- This number is the total number of systems forecasted to ship in that month.

Part of the spreadsheet used is shown as an example in Figure 3. This task is done every week, with the first week of the month generating the official forecast and subsequent weeks tracking progress and making adjustments.

FORECAST SHIPMENTS -- WORKSHEET			
<i>July Wk1</i>		PIPELINE	
TL	Pipe	% Close	FCST
Firm/Shipped to Date	0	100%	0
Pending SD	0	90%	0
90-99%	112	46%	51
80-89%	284	24%	68
70-79%	659	6%	42
60-69%	550	8%	46
50-59%	122	16%	19
Subtotal	1727		225
UNFORECASTED		Mo. ave	700
FCST Total		Forecast	925

Figure 3 – Sample Forecast Worksheet

2.2.2 Consolidating Market Segment Forecasts

Once each market segment determines the total number of master packs it expects to ship, the forecasting manager consolidates the numbers into another spreadsheet called the forecast spreadsheet. The forecast spreadsheet has formulas based on historical shipment data that calculate how many of each type of master pack will ship (i.e. what percentage of the total forecasted shipments). To finalize the forecast, the forecast manager and forecast analyst meet to compare what the forecast spreadsheet calculates against configurations shown by the CRM software data. Any discrepancies are resolved by giving precedence to the software data, and adjustments are made on the forecast spreadsheet. The forecast spreadsheet is then published as the official monthly forecast for the organization.

2.3 Tasks within the Manufacturing Organization

Once the monthly forecast is published, the next tasks in the forecasting process are performed in the manufacturing organization. This section focuses on how the forecast is used in the Manufacturing organization. First, some background on the QWBS supply chain is given followed by a description of how the forecasts are used within that context.

2.3.1 QWBS Supply Chain

The QWBS supply chain uses a postponement strategy or push-pull system, where parts are procured per the forecast and systems are configured to order. In a push-pull system, forecasts are used in the long lead-time part of the supply chain, in essence, pushing. In the shorter lead-time areas a pull system is used to better serve customer demand. Simchi-Levi, et al explains how to determine when to push and when to pull. “Since aggregate demand information is more accurate than disaggregate data, the push portion of the supply chain includes only activities and decisions made prior to product differentiation. These activities are based on aggregate demand data... [The] push-pull boundary [is located] in order to achieve a balance between the advantages of the push and the pull-based systems.”⁴

At QWBS the picture is much more complex. This is due to the many different ways inventory is managed. An idealized version is given here for illustration purposes. The material is pushed by forecasts sent to the suppliers. The suppliers hold the inventory until it is needed, when it is ready to ship. As demand is realized, the factory will pull the inventory from suppliers and configure to order. There are also inventory buffers at various points to ensure good customer service and factory flow. A simplified diagram of the supply chain is given in Figure 4.

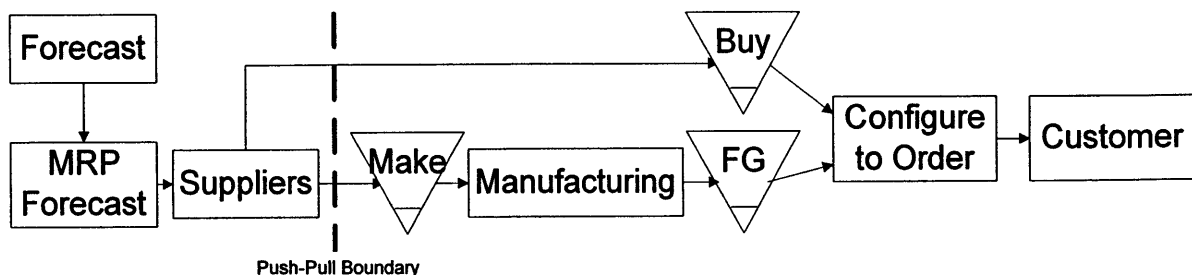


Figure 4 – Simplified QWBS Supply Chain

2.4 Problems with the Existing Process

While the forecasting process was basically sound, several problems and issues were identified in the existing process that prevented the most successful outcomes. For one, there was inconsistent use of processes already in place. Other issues were more fundamental, in that the end result of a task is not meeting the all the needs of the next customer in the process. A lack of trust and issues with communication were also problems.

2.4.1 Use of the CRM Software

There were several issues with the usage of the CRM software. Major issues have to do with consistency of use, reliability of the data, expectation of perfection, and creation of forecasts from the data in the software.

Inconsistent Use of CRM Software

According to the forecast analyst who uses the data, the sales organization's use of the CRM software has been inconsistent and non-uniform. The shipment probability of one sales person is not the same as the shipment probability of another. While this is to be expected, there are big differences from one person to the next. Missing information like the shipment date or expected configuration is another problem. In one case a sales person hadn't input the possibility of a sale at all. He was quoted as saying, "We've been working on this a long time, but we didn't want to say anything because we weren't sure." One of the other major struggles has been the time lag in updating customer information.

Information in the CRM Software is Suspect

Along with inconsistent and non-uniform use, many times the information in The CRM software was not reliable. While a lot of the time the information was accurate, the shipment probabilities and the configuration at times both proved to be inaccurate when the actual order came through. Though historical configuration information is used, precedence is given to information from the software. The forecast analyst decides whether that information is judged to be reliable or not. Much of this stems from the limited future visibility QWBS' customers experience and sales people who, "don't want to bug them to the extent where they find it difficult to do business with us." This phenomenon is also explained by Flugstad who shows, "that a probability estimate, albeit numerically precise, can be flexibly interpreted at an intuitive

level depending on the reasons that the forecaster provides as the basis for the estimate.”⁵ At QWBS this happens during the forecast conference call where context is given to the estimates.

“Un-forecasted” Sales

One of the expectations in the organization is that a majority of shipments should be accurately predicted from the CRM software. This expectation has proven to be a difficult one to attain. One of the statistics measured by the forecasting department is “un-forecasted” shipments. An “un-forecasted” shipment is one that was not predicted in the software for that month at a 50% or greater shipment probability. During ten months of FY2002 fifty percent of shipments were “un-forecasted.” This caused trepidation on the part of the forecast analyst who said several times, “If that un-forecasted number goes to 100%, I don’t need to come to work.”

The expectation of the majority of shipments being predicted in the software is unrealistic and troublesome due to a few facts. First, for seven months of FY2002, 91% of the “un-forecasted” shipments went to existing customers. Second, the majority of existing customers don’t deal with the sales organization on a regular basis. In an interview, one of the sales managers indicated that the customer service organization is only staffed to contact existing customers once every three months. These customers also have the option of ordering directly through the web, or calling in an order. It is clear from these facts that, unless something changes with the current system or staffing levels, these customers won’t be forecasted accurately. Such ongoing, unmet expectation provokes feelings of mistrust amongst the functional areas of the division.

Creating the CRM Software Forecast

From a probabilistic viewpoint, deleting all predicted shipments with probabilities less than 50% is like cutting off half the distribution. This type of practice skews the data. In practice, anything assigned a probability of less than 50% was more of a placeholder than a true assessment of shipment probability. This practice was reinforced when the weighting factors for those probabilities were found to be zero as well.

2.4.2 Manufacturing’s Needs are not being met

Another issue with the forecasts is that they do not meet all of the needs of one of their users – manufacturing. As discussed earlier, manufacturing is able to configure to order within the customer lead-time. Procurement of components takes longer than customer lead-time and is where a forecast is needed.

2.4.3 Measurement of Forecast Error

The problem of measurement is simple. In this case, it isn't done in a way that will help one of the end users of the forecast. The first problem with measurement is that forecast error is only measured at the level at which the sales organization is measured (i.e. did we hit our quota of total sales dollars?). Forecast error at the master pack level is not measured. The forecast error for the most common master packs for 11 months of FY2002 was reconstructed and is shown in Table 1 below. The forecast error is measured by the mean absolute percentage error or MAPE.⁶

Common Master Pack Forecast Error Percentage (MAPE)						
Master pack	ACU w/DU	ACU w/EDU	ACU w/GPS, EDU	ACU w/GPS, MVPc	OmniExpress w/EDU	OmniExpress w/MVPc
MAPE	37%	30%	108%	42%	115%	220%

Table 1 – Common Master Pack MAPEs

Two cross-industry benchmarking studies showed the average forecast error to be 23%⁷ and 30%⁸ at the SKU level respectively. When compared to these benchmarks, the forecast error at the master pack level, as shown in Table 1, is high.

2.4.4 Use of the Forecast

How forecasts are used is another major issue. With no forecast error measurement, safety stock levels in the push section of the supply chain are based on someone's intuition. In the pull section of the supply chain, neither forecasts nor history are used effectively to set finished goods buffer levels. Instead, these levels have been set based on a multiple of the number of systems that can fit on a pallet. Other problems with the usage of forecasts are detailed in the next section.

2.4.5 Communication and Trust

William Safire once wrote, “In economics as in politics, secrecy generates suspicion. Disclosure, especially in detail, begets the bored yawn of confidence. We can use a little more of that trust this year.”⁹ At QWBS manufacturing questions whether the sales organization knows further in advance what the customers want and doesn’t share the information. The following two quotes illustrate the prevailing feeling that there is little disclosure of information provided to manufacturing. The manager of procurement said, “As you know, we’re playing the beer game¹...” And the master scheduler said, “I tweak the data because I don’t believe it.” It is very clear that trust is lacking. Even for those who have played the beer game it is hard not to get caught up in the feelings of frustration and mistrust. As seen by the master scheduler’s quote such feelings lead to behaviors that amplify the negative effects. To compensate, manufacturing does many things with word of mouth and scrambles and expedites to make things happen.

¹ The beer game was developed at MIT by Sloan's System Dynamics Group in the early 1960s as part of Jay Forrester's research on industrial dynamics to illustrate the dynamics involved in even a simple supply chain.

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3 AN IMPROVED FORECASTING PROCESS

While there are several significant problems with the current forecasting process, there is a good foundation upon which improvement can be made. To improve the forecasting process at QWBS a framework has been developed. This framework has recommendations specifically addressing the improvement of forecast creation, use, and communication. As a result of these recommendations QWBS chartered eight process improvement teams and several of the recommendations have been implemented. The details of each of these are discussed below and Table 5 provides a summary at the end of this chapter.

3.1 Improving Forecast Creation

There are three major aspects to improving the creation of forecasts at QWBS. First, improve the reliability and integrity of the CRM software by establishing guidelines for its use. Second, align the output of the forecast with the needs of manufacturing by forecasting components rather than master packs. Third, use all available information by combining an historical based forecast with the forward-looking forecast from The CRM software. The combination of these three aspects is expected to reduce the forecast error an average of 10% - 20% (based on the results of a sample test case). The details of each of these aspects follow.

3.1.1 Guidelines for Use of the CRM Software

In order to improve the reliability and integrity of the customer data within the CRM software, guidelines for its use need to be established. These guidelines must address the two major issues of the sales organizations' use of this software. First, rules for updating the system need to be created and implemented. Second, guidelines to aid sales people in assigning shipment probabilities must be developed.

Rules for Updating the CRM Software

The information in the CRM software must be up to date and accurate when it is being used to predict monthly shipments. As described previously, the use of this software has been non-uniform and inconsistent. To remedy this situation, rules for the usage of the software need to be developed. An example of a rule is that all customer data must be updated every Friday. Another example is that certain fields in a form must be filled in or the data will not be used. The defining of these rules, or the process, should be a joint effort between those who enter the data (sales

organization) and those who use the data (forecasting department). Once appropriate rules are developed and followed, trust in the data integrity can be built.

Aiding the Assignment of Shipment Probabilities

As described earlier, sales people tend to assign shipment probabilities based on ‘gut feel.’ The sales force at QWBS is very experienced and its instinct has been a valuable source of information. Developing guidelines to aid instinct when determining shipment probabilities will help sales make better judgments. A study by Rakow, Harvey, and Finer shows the benefit of using guidelines to aid in forecaster assignment of probabilities. The experiment shows “beneficial effects of providing people with a range of probability responses derived from a statistical model.”¹⁰ The guidelines in the study served as “judgment anchors.”¹⁰ A set of guidelines has already been developed and needs to be validated and enhanced. Once developed, it is crucial to ensure consistent application and use of the guidelines. It should be noted however that these are “guidelines” and are not a replacement for sound judgment or a sales person’s instinct.

An example of what these guidelines might look like is helpful for illustration purposes. Suppose there are three stages in the sales cycle – contact, proposal, and contract. Each customer must progress through each of the stages. An average time is needed for a customer to progress to the next stage. To develop guidelines, a study can be performed to determine how long it takes a customer to order, given its stage in the sales cycle and the closure percentages. The guidelines would then be something the sales person could look at, compare the particular customer with the historical average of similar customers, and then assign a probability.

Benefits of the Guidelines

The goal of these changes is to have up to date and consistent data to use in creating forecasts. The development of rules for updating the CRM software is intended to help formalize efficient use of the tool. The development of guidelines for assigning probability is intended to help sales people assign more realistic probabilities. These changes are not far from the current sales practices and objectives. This software package had only been widely used for less than a year, so there had been several issues with training and accuracy of data. These problems seem to be working themselves out as the sales people become more familiar with the tool, but the practices still need to be more consistent and uniform. The benefit of consistency in use of the software is that the rest of the organization will know it has the most up to date information available and a

meaningful assignment of shipment probability. Consistent use of these tools will aid in building trust and help alleviate second-guessing of the forecast.

3.1.2 Using Risk Pooling to Improve Accuracy

Besides improving the data integrity in The CRM software, significant improvements can be made to the forecasting process by forecasting components instead of master packs. The improvements come in two ways. First, improvement comes by aligning the output of the forecast with the needs of those who use it. Second, improvement comes from reduction of demand variability and resulting positive effects on forecast accuracy. Before discussing the specifics at QWBS, some background on the risk-pooling concept is useful.

Risk Pooling Background

The risk-pooling concept has been used in several arenas to create improvements. Examples range from reducing investment risk through diversifying a portfolio to reducing inventory through use of a postponement strategy.¹¹ Risk pooling takes advantage of statistical facts when adding multiple streams of demand.

One of the most widely used, but powerful, concepts in statistics is that of the normal distribution. The two components are the mean and standard deviation. The variance is the standard deviation squared. As proven in many places, when adding variables from two distributions, the means and the variances are summed to determine the new mean and standard deviation, assuming the two distributions are independent.¹²

Yet, risk pooling will still reduce the demand variability when the distributions are anything less than fully correlated. Roza shows, “that the standard deviation of the sum of many random variables is at most the sum of the standard deviations. Also, any scenario with less than perfect correlation will yield a smaller standard deviation for the sum. This concept is the theoretical driver for the concept of ‘risk-pooling.’ Risk-pooling of multiple demand streams decreases the total demand variability and thus the total required safety stock.”¹¹

An example of the application of this concept is found in Roza’s work in 1997 at Bay Networks.¹¹ He showed how the concept of risk pooling could improve forecasts for motherboards. By forecasting the components of the motherboards and configuring them to order, Bay Networks was able to have better customer service with lower inventory levels.

Demand is Less Variable at the Component Level

To apply the risk-pooling concept at QWBS, the demand variability of the major master packs was compared to the demand variability of the major components. A common statistical measure of variability is the Coefficient of Variation or CV. The CV is the ratio of the standard deviation to the mean for a set of data. Tables 2 and 3 shown below, compare the monthly demand variability of the most common master packs with the monthly demand variability for the common components.

Common Master Pack Coefficient of Variations (CV)						
Master Pack	ACU w/DU	ACU w/EDU	ACU w/GPS, EDU	ACU w/GPS, MVPc	OmniExpress w/EDU	OmniExpress w/MVPc
CV	.36	.25	.72	.73	.99	1.34

Table 2 – Common Master Pack CVs

Common Component Coefficient of Variations (CV)					
Component	ACU	ACU w/GPS	EDU/DU ²	MVPc	TMCT
CV	.25	.41	.26	.40	.91

Table 3 – Common Component CVs

The two tables show that the monthly demand variability of the common components is less than the monthly demand variability for the master packs. This is the expected conclusion from the concept of risk pooling, given that, in this example, there are fewer components than master packs. This conclusion is now supported by data for the QWBS case.

The Forecast can be more Accurate at the Component Level Using History

A major component in determining expectations for the accuracy of a forecast is the demand variability. Less variable demand leads to more accurate forecasts. Forecasting components and

² In October 2002 the DU was no longer sold domestically. An upgrade to the EDU was given when customers requested the DU. The analysis grouped the demand for the DU and EDU together for this reason.

using history can be more accurate than current methods. A common statistical forecasting method is the Holt-Winters method of exponential smoothing. This method is discussed in more detail in section 3.1.3. The results of a few forecasting test cases, as measured by the MAPE, using the Holt-Winters method, are shown in Table 4. Table 1 is shown again for comparison purposes. Remember the benchmarking studies showed the benchmark MAPEs at the SKU level to be between 23% and 30%.

Common Master Pack Forecast Error Percentage (MAPE)						
Master pack	ACU w/DU	ACU w/EDU	ACU w/GPS, EDU	ACU w/GPS, MVPc	OmniExpress w/EDU	OmniExpress w/MVPc
MAPE	37%	30%	108%	42%	115%	220%

Table 1 – Common Master Pack MAPEs (duplicated)

Common Component Forecast Error (MAPE)				
Component	ACU	ACU w/GPS	EDU/DU	MVPc
MAPE	20%	40%	20%	40%

Table 4 – Common Component MAPEs

These forecast improvement examples are only test cases. Exact replication of the results should not be expected. We have demonstrated that accuracy can be improved significantly by forecasting at the component level.

3.1.3 Combining Sales Insight with History

By forecasting at the component level, the output is aligned with the users’ needs and reduced demand variability improves the forecast accuracy. Remember that a significant portion of customers don’t regularly interact with the sales force. How do we improve the accuracy when there is no forward looking prediction or data from the sales force? The way to capture these needed improvements is through the use of statistical methods based on historical data. By using

historical data, we may better predict the mix of components we will need. Combining that with the sales peoples' insight we should be able to have a more accurate forecast. Formalizing the task of generating forecasts adds discipline to the activity, which helps the process to be more than someone's "best guess", and provides a defined process that others can see.

Historical Forecast

Historical forecasting may be performed in several ways. Initially, in order to align the output with the needs of manufacturing, a forecast will be generated for each of the major components. For uncommon components, the Automated Inventory Management (AIM) system developed by Jim Anderson will be used.¹³ AIM uses the base-stock model as Graves describes.¹⁴ A strong candidate method for historical forecasting is the Holt-Winters method of exponential smoothing. Two aspects make the Holt-Winters method of exponential smoothing a strong candidate. First, this method accounts for trend, growth and seasonality in the demand pattern. This method should work well, as QWBS's sales are growing and it experiences seasonality in demand. Second, Microsoft Excel is used and more complex forecasting algorithms would necessitate additional forecasting software. A basic implementation of the Holt-Winters method is described on the Engineering Statistics Handbook website.¹⁵ Mentzer and Gomes describe a more complex and accurate algorithm.¹⁶ Both of these are easily implemented using a spreadsheet. However, there are inexpensive forecasting software packages that are add-ins to Excel. One of these packages has been purchased. The software chooses the forecasting algorithm with the best statistical fit to the historical data. Tests of the software verified that Holt-Winters is an appropriate and more accurate method for QWBS' historical demand patterns.

CRM Software Forecast

A CRM software based forecast is still needed to capture information about customers gained through the sales process. This can be created in a way similar to the current method. The process should be improved in a few ways. One way to improve is to document and formalize the tasks more fully than the current effort has done. Doing this will enable the sales organization to continually improve its use of the tool. Another improvement is to utilize all the available information. This would mean not discarding the data with a probability of less than 50%. This data could be used to generate probability distributions for each component. Generating probability distributions for components is an objective way of utilizing the configuration information. These distributions could then be compared to the historical based forecast.

Combining the Historical and CRM Software Forecasts

Combining the Historical and the CRM software forecasts is crucial to benefiting from the information contained in each. To combine the two forecasts, the historical forecast is aggregated to the total system level (same as the CRM software forecast); and then they are blended based on set rules. Some possibilities for setting the rules are to average the two forecasts, or give one forecast more weight than the other and have a weighted average. Another possibility is to use the historical forecast as a baseline and make adjustments up or down based on the CRM software forecast.

Logistics for Combining History with Sales Insight

Since creating forecasts is a team effort with the sales organization and the forecasting department, some discussion of logistics and responsibility is warranted. The new process has a few steps. First, the forecast analyst creates both the historical forecast and the CRM software forecast and combines them using the agreed upon rules. This is a preliminary forecast. During its weekly conference call, the sales organization makes any adjustments and gives final approval. The approved forecast is the official forecast for the month and is published for the organization. In this new process the forecasting department is not a number consolidator, but takes on an active role in forecast generation. Yet, the sales organization still has the responsibility for approving the final forecast number.

What Goes to Manufacturing

A forecast spreadsheet still goes to Manufacturing for upload into The MRP system. The difference in the recommended process is that there is a forecast for each of the major components and not a forecast for each master pack.

3.1.4 Forecast Creation Process Flowchart

Figure 6 is a flowchart showing the recommended forecast creation process. The flowchart also shows the recommendations for forecast error measurement, forecast revision, and joint business decisions, which are described in sections 3.2.1, 3.3.1, and 3.3.2 respectively.

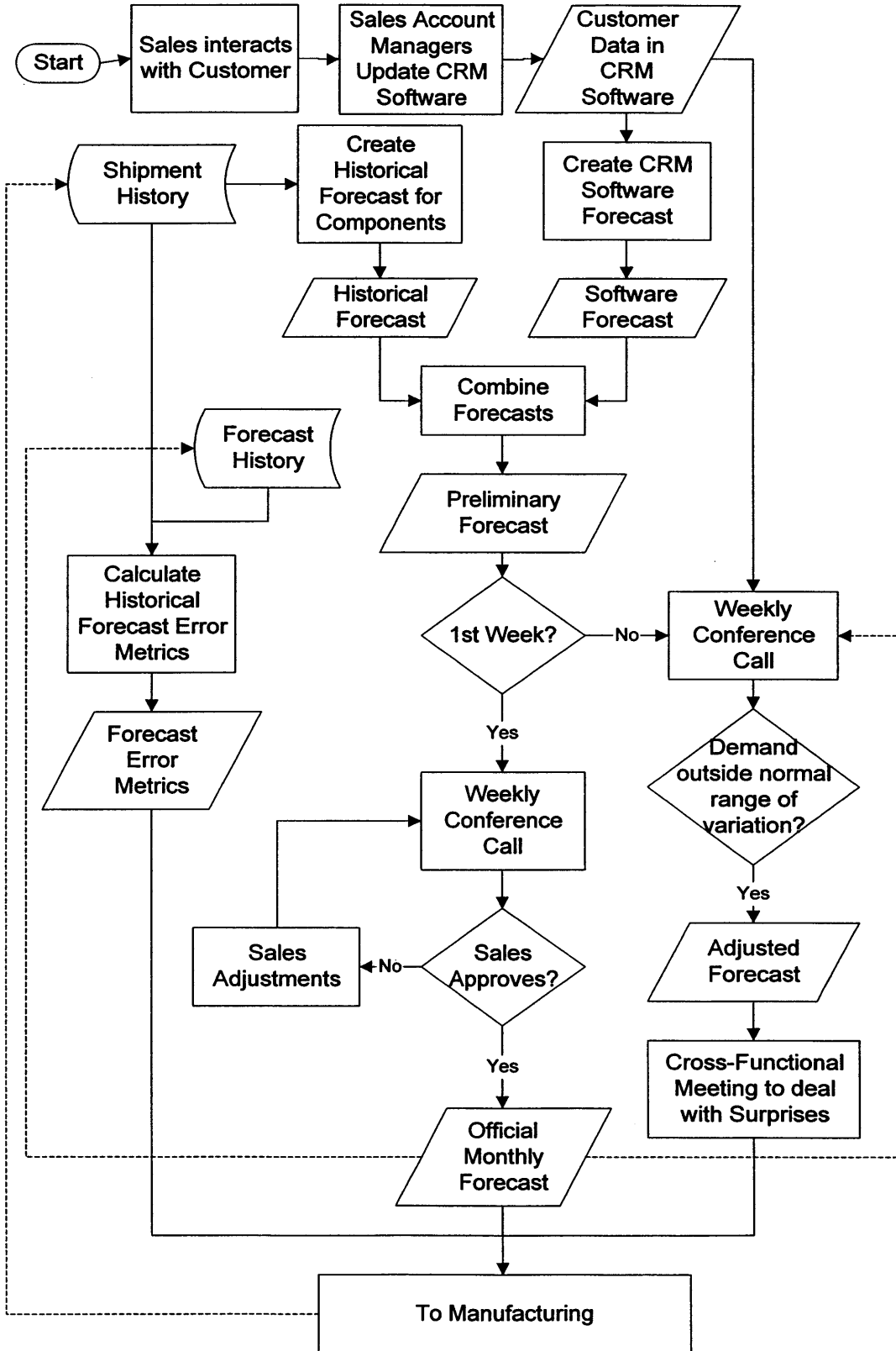


Figure 6 – Recommended Forecast Creation Process Flowchart

3.2 Improving Forecast Use

Even a perfect forecast will not help anyone unless it is used properly. This section outlines a few changes that can improve the use of these forecasts. The first improvement will be to measure the error of the forecast. Second, this error will be used to set safety stocks in the push section of the supply chain. Third, buffer levels will be set based on historical customer demand in the pull section of the supply chain. The combination of these three changes will decrease the chance of stock out while reducing the effort needed to make it happen.

3.2.1 Measuring Forecast Error

As stated earlier, the forecast error is measured at the total shipment level. This effectively measures the forecast performance of the sales force, but does not help the manufacturing organization plan for uncertainty in demand. In conjunction with forecasting components, measuring the accuracy of forecasts at the component level will aid in planning for the uncertainty. There are several common measures of forecast accuracy that can serve a dual purpose. One is to highlight areas that need improvement. The second is to provide an input into setting inventory safety stock levels. These measurements are a good start, but more information and improvements can be gained by using statistical process control. Measuring the forecast error and reporting it fosters openness with the process and provides focus to areas that need improvement. The data monitoring the forecast quality will lead to “the bored yawn of confidence.”⁹

Common Measures of Forecast Error

Two common measures of forecast error are the mean absolute deviation (MAD) and the mean absolute percentage error (MAPE). The MAD measures the absolute value of the difference between the forecast and the actual value. The absolute value is used so that positive and negative misses don't cancel each other out. The MAPE is a measure of the error that is independent of the volume, making it useful for comparison purposes and benchmarking. It is the ratio of the MAD to the actual data. MAD and MAPE are widely used to measure forecast error, as noted by two articles.^{6, 7} The standard deviation of forecast error is the measure that will be input into the calculation of safety stocks. This is calculated through standard statistical formulas from the difference between the forecast and the actual values.¹²

Statistical Process Control

Another way to monitor the forecast is through statistical process control (SPC). “The essence of process control is making the most of variation. There is variation in everything we do, and the pattern of this variation is a key source of information. By appropriately stratifying the data...we can make the right decisions to improve the performance of people and their tools.”¹⁷ The control charts used with SPC will help the forecast department to improve the process in several ways. Process monitoring can better diagnose and explain when abnormal variation occurs. Consistent bias in the forecast (high or low) will be seen, and adjustment to the process can be made.

3.2.2 Setting Safety Stock levels

With a measure of the forecast error for the major components, planning for uncertainty in demand is an easier job. Using the error measurement to set safety stock levels is one way to do this congruent with the QWBS system. This is a standard practice that will serve to link the forecast to the supply chain. Inventory levels at QWBS may not be reduced through this practice because of supplier practices already in place. Reductions in expediting costs will be a benefit.

Calculation for Safety Stocks

Recall that QWBS procures parts to the forecast and then configures master packs to order. The suppliers are the push section of the supply chain where forecasts are needed and important. The forecast will not be exact, requiring safety stocks to buffer against the uncertainty. Mant asserts that safety stocks should be set based on forecast accuracy.⁶ The safety stock level is calculated by multiplying the standard deviation of forecast error over the replenishment lead-time by a safety factor for a given service level.¹⁸ The measurement of the forecast error facilitates setting the safety stocks based on this model.

This differs from present practice in that a formula rather than intuition is used to calculate the level of inventory. Buyer judgment is still needed with low dollar or high dollar items to ensure too little or too much inventory isn't held. This method provides a tool for procurement to calculate the amount of safety stock the suppliers should hold.

Effects on Inventory

Minimal effects on inventory at QWBS will result from this change. This is due to the way inventory is managed for the majority of components. Remember that forecasts are sent to

suppliers where inventory is held until it is needed. Because of this it is expected that there will be minimal effects on inventory at QWBS.

Savings from Less Expediting and Scrambling

Given the prior work done to reduce inventory, the savings associated with linking safety stocks to forecast accuracy comes mainly from reductions in expediting costs and the buyer time associated with it. The procurement organization conducted a study on expedited shipments. Of those shipments, it was estimated that 40% - 60% were due to forecast inaccuracies. With the new policies for setting safety stocks and setting finished goods buffer levels (covered in the next section), the majority of these expedited shipments is expected to be eliminated. Using the 40% - 60% range, the expected savings from reductions in expediting costs and the related buyers time is a significant portion of that cost.

3.2.3 Finished Goods levels

Setting safety stocks based on forecast error helps the push section of the supply chain. A different tactic is needed in the pull section of the supply chain, where forecasts are not used. Recall that in the ideal case the factory pulls material and builds product only based upon customer demand. This practice has been one of the drives in manufacturing when implementing Demand Flow Technology (DFT). DFT is a version of lean manufacturing taught by Costanza.¹⁹ Even at the component level, demand is highly variable necessitating finished goods inventory to buffer the variability. The finished goods are used to configure an order when it comes. Setting buffer levels based on historical customer demand over the replenishment lead-time will ensure QWBS provides the high level of service it is accustomed to.

Calculating the buffer level is best done using standard tools. The Base-Stock model¹⁴ has been used effectively in many environments to set inventory levels. Milby shows how the Base-Stock model fits with and complements lean manufacturing (or DFT) techniques.²⁰ The AIM tool¹³ discussed earlier is an automated implementation of the Base-Stock model that QWBS is already using. Extending the use of AIM to set buffer levels will ensure the lowest inventory level to meet customer demand with a high level of service at the lowest cost.

3.3 Improving Communication

Having a more accurate forecast and tools to better utilize it does not fully solve the fundamental organizational problems of mistrust and poor communication. We offer two main suggestions for improving communication. These are defining a process for forecast revision and communication, and a process for making business decisions when demand falls outside the predicted range.

3.3.1 Forecast Revision

In the past the forecast was revised weekly. The practice of setting safety stocks based on forecast accuracy reduces the need for frequent revision. The new policy warrants forecast revision only when significant changes in demand occur. The decision to revise the forecast occurs during the weekly forecast team conference call. The team determines if there is a significant change in demand expected to exceed the safety stocks. Changes are communicated to manufacturing by the forecasting department.

The reduction in frequency of forecast revision reduces the need for weekly meetings held with sales, forecasting and manufacturing. These meetings are needed only to communicate revisions to the forecast. A benefit of meetings to communicate changes is in the maintenance of relationships. “Face-to-face contact is crucial in the initiation of relationships and collaborations, and people are more cooperative when interacting face-to-face than via other forms of communication. Personal, face-to-face contact is the lubricant of the business engine. Without it, things do not move very well, and relationships between people are often strained and contentious.”²¹ Maintenance of good relationships among people and groups within QWBS is crucial element of the trust inherently needed for effective cross-functional, cross-organizational processes.

3.3.2 Joint Business Decisions

It is great to have a streamlined process for forecasting. But what happens when there is a large customer order received with little advance notice (within the component lead time)? In these instances, it is important for the sales organization to determine what configuration the customer needs. Managing customer expectations is another important task in these instances. Determining the configuration earlier for large orders allows manufacturing to plan for and

communicate supply challenges early enabling the management of customer expectations. When expediting or overtime is needed to meet the customer demand, a cross-functional team will meet to decide the best course of action. The team will weigh the costs versus the benefits of meeting customer demand immediately. This exercise facilitates better decisions for QWBS not solutions favoring one department.

One of the decision tools needed by this team is a model of supply chain capacity. The capacity model will determine the costs and the limits to meeting customer demand immediately. Costanza refers to this as a “Flex Fence”¹⁹ for the factory and the supply chain. What the model will show is a range of capacity for a given lead-time and the extra cost associated with exceeding that capacity. It will give the team needed information to feed back to the sales organization, which will then manage customer expectations.

Summary of Recommended Changes Improving the Forecasting Process			
Existing Process	Issues	New Process	Benefits
Use of the CRM software is Not Consistent	<ul style="list-style-type: none"> - Inconsistent or Incomplete Assignment of Probabilities - All information is not available. 	Develop Guidelines for Consistent Use of the CRM software	<ul style="list-style-type: none"> - Up to Date and Reliable Information - Shipment Probabilities are More Realistic
Forecast All Customers Using the CRM software	<ul style="list-style-type: none"> - High “Un-Forecasted” Shipment Number - Sales Force Focuses Effort on New Customers, Interaction with Existing Customers More Limited 	Combine the CRM software Forecast with a Statistical Historical Forecast	<ul style="list-style-type: none"> - More Accurate Forecast for all Customers - More Accurate Forecast at the Component Level
Forecast Master Packs	<ul style="list-style-type: none"> - Demand variability is High - Forecast Error is High 	Forecast Components	<ul style="list-style-type: none"> - Component Demand Variability is Lower - More Accurate Forecast at the Component Level
Master Pack Forecast Error not Measured	Forecast Accuracy is not Known	Forecast Error Measured at the Component Level	<ul style="list-style-type: none"> - Disclosure of Information Builds Trust - Used for Continuous Improvement
Safety Stock Set Based on Buyer Intuition	<ul style="list-style-type: none"> - Will Inventory Levels Meet our Needs? - Lots of Expediting to Meet Demand 	Safety Stocks Set Based on Forecast Error	<ul style="list-style-type: none"> - Tool to Set the Needed Amount of Inventory - Less Expediting to Meet Demand
Finished Goods Buffers Set Based on Factory Ability or Container Size	<ul style="list-style-type: none"> - Will Inventory Levels Meet our Needs? - Lots of Expediting to Meet Demand 	Finished Goods Buffers Set Using Base-Stock Model	<ul style="list-style-type: none"> - Tool to Set the Needed Amount of Inventory - Less Expediting to Meet Demand
Frequent Forecast Revision	<ul style="list-style-type: none"> - Confusion About Needs - Fuels Mistrust 	Forecast Revised When Demand is Outside of Historical Forecast Error	Less Forecast and Supply Chain Volatility
Manufacturing Spares No Effort to Meet Unexpected Customer Demand	<ul style="list-style-type: none"> - Lots of Expediting to Meet Demand - Higher Product Costs 	Joint Business Decisions about Large Unexpected Customer Demand	Best Decision for Whole Organization is Made

Table 5 – Summary of Recommended Changes Improving the Forecasting Process

4 IMPLEMENTING AND LEADING CHANGE

Having a great technical solution to a problem will take you nowhere unless you are able to implement it and help people to change they way they do things. Leading people to make these changes was a significant part of the work at Qualcomm and merits discussion. I will first talk about the organization in terms of the three lenses. With that context established, I'll then relate the change effort to the Sloan Leadership model. Finally, I will talk about the results of the change effort.

4.1 The Three Lenses

The “three lenses” is a term used by Ancona, Kochan, Scully, Van Maanen, and Westney.²² When someone says he is using the three lenses he is examining their situation from three different perspectives used for analyzing organizational processes: strategic design, political, and cultural. Sometimes, looking through one lens changes your view of things observed through another lens. What follows is a discussion of the project from the perspective of each of the lenses.

4.1.1 Strategic Design

The strategic design lens looks at the project through the perspective of the formal structure and strategy of the organization. To gain insight from this perspective it is important to look at formal structure and the strategy of QWBS, and examine how these things may help or hinder the project. Careful examination shows that the organization is one where consensus is needed to make things happen, but once this is gained the changes can move forward quickly.

Organizational Strategy

The goal of improving the accuracy and use of forecasts complements the current organizational strategy. At a high level, QWBS' strategy is to improve its market position through providing superior products and services with the highest level of customer service and lowest possible operating cost. The current economic and market environment has made forecasting and achieving low operating costs more difficult. One director summarized the value and strength of Qualcomm's products in a growing market when he said, “Up until two years ago we would pick a number and hit it.” Improving the accuracy and use of the forecasts dovetails

well with this strategy, as better forecasting allows for better servicing of customer needs at lower costs.

Organizational Structure

The organizational structure at QWBS necessitates consensus solutions to cross-functional problems such as forecasting. A simplified organization chart is shown in Figure 7 below. The figure shows that QWBS is divided along traditional functional lines. Only the functions most affected by this project (i.e. Sales, Finance and Manufacturing) are shown for the sake of illustration.

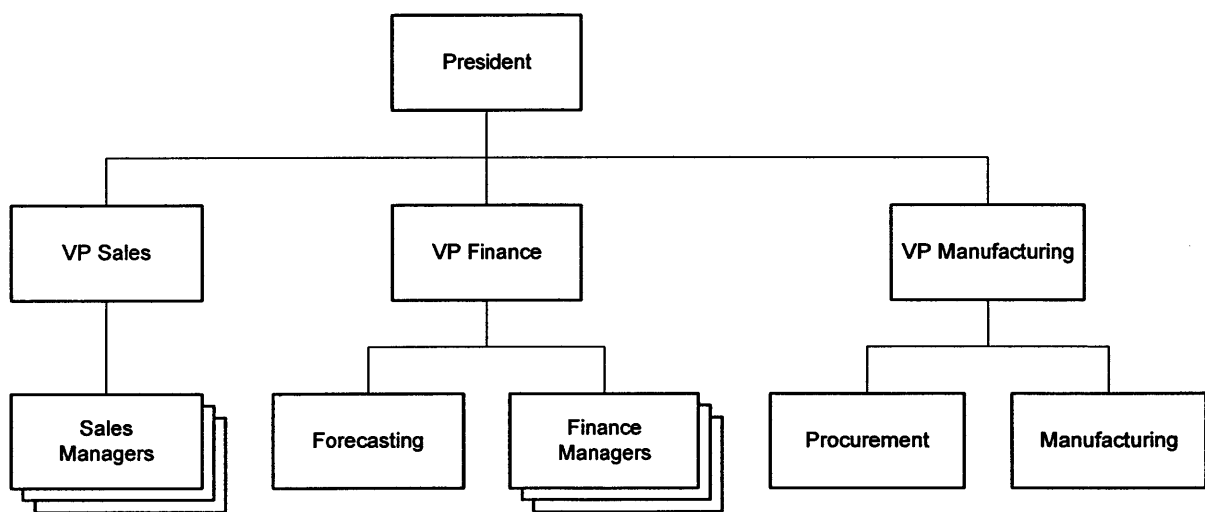


Figure 7 – QWBS Organization Structure

By its nature, the process of creating and using forecasts coordinates the efforts of many functions. When trying to improve such processes, it is critical to get the several functions to agree. In this case it was imperative to get agreement from the VPs of Sales, Finance, and Manufacturing as well as those who actually do the work at lower levels. To achieve agreement, the improved process had to balance the needs and incentives of these three varied functional groups. By doing this there is no need to make any changes to the formal structure.

The way QWBS has designed jobs was also a significant influence to the work on this project. Specialization in jobs follows naturally from a functionally aligned organization structure. At QWBS there were many jobs that touched the forecasting process. This increased the need for consensus decisions regarding improvements to the process.

On the plus side, despite being organized along functional lines and having job specialization, there is a strong informal network in place that bridges the gaps across the formal structure. In the literature, these gaps are often called structural holes, and tight linkage within a functional group is called closure. Burt showed how “brokerage across structural holes is the source of value added, but closure can be critical to realizing the value buried in structural holes.”²³ This phenomenon is referred to as social capital. In the case of QWBS, there is good closure within functional groups, and there are several people who fill in the structural holes, so it can be considered to have high social capital. A good example of this is that of the forecasting manager. He was previously the master scheduler moving from the manufacturing to the finance organization. In this new role, his formerly closed network now bridged across the structural hole, thus creating social capital. The high social capital or strong informal network within QWBS serves as a coordinating system to support needed changes and quick action.

While the informal network at QWBS is strong and can get things done quickly when the situation warrants, there are cases where the informal network is insufficient. In these cases, there is the formal system of process improvement teams. This system formally brings together cross-functional teams to address specific issues. One of the major results of this project has been the charter of eight separate process improvement teams. These teams evaluated further the eight major process improvement suggestions and implemented several of them. The teams were all led and coordinated by the forecasting manager.

4.1.2 Political

As its name suggests, the political lens looks at the project through the perspective of the political aspects of the organization. This perspective tries to understand the different interests and goals that guide individuals, groups, and departments both within and outside of the organization. Looking through the political lens in this context shows that all parties were agreed that a change was needed, but had not agreed on what that change should be. We discuss further what each party’s interests were and how their sources of power came into play.

Interests

One way to gain insight into the political aspects of the organization is to identify whom the stakeholders are, determine what their interests are, and consider whether they can be aligned. An important question to ask is, “What does each stand to gain or lose from the project?” In the

case of this project, the key stakeholders are those identified previously – the leaders of the Sales, Finance, and Manufacturing organizations. The question of what each stands to gain or lose depends solely on what solution is being offered and whether it favors one function over another. For example, the Sales organization wanted something that would benefit the whole division, yet it strongly desired a significant portion of the work to address Sales' tasks within the process. On the other hand, at the outset Manufacturing felt like it was doing the best they could and Sales needed to improve.

One of the methods of better understanding the different stakeholders is to make a map. On the map an indication with pluses and minuses of whether they are for or against the project helps to identify where political effort is most needed. Showing a stakeholder map here would be of little value, since all were agreed a change needed to happen. The difficulty was discovering what changes would be acceptable to each, and crafting a proposal that would benefit everyone.

When all parties are agreed on change, conditional on their interests being addressed, it is important next to determine what those interests are. In our case by addressing all concerns and communicating issues each party had with the current system, a consensus agreement was reached on what would be best for everyone. A key to this was building on the common interest of serving the customer. Each area had differing concerns. For example, the Sales Organization was concerned with making sales regardless of the configuration. On the other hand, Manufacturing was concerned with lowering inventory levels and was greatly affected by forecast inaccuracies. The bottom line for both was that they wanted to serve the customer well.

By discussing the situation, outlining constraints and possible compromises, the interests of all the parties changed into better alignment. In this case, both Manufacturing and Sales could see that their needs were not mutually exclusive. Fortunately, the proposal that was developed and accepted was one that balanced the needs of all the stakeholders. In negotiations terms, this was an integrative or mixed-motive negotiation. The key to this success was exploiting the differences in the parties' interests so that everyone felt that they were winning.²⁴

Sources of Power

Another aspect of looking through the political lens is determining what sources of power the various parties bring to the initiative, how the power is distributed among them, and how the outcomes might change this. QWBS is a very customer focused organization. This means that the closer you are to the customer the more political clout you carry in the organization. The

sales organization in this context is the closest to the customer. With the imbalance of political power in the organization, it was key to get buy in from the VP of Sales for the project. Fortunately, he was most interested in what was best for QWBS as a whole. One key political maneuver was to help him realize that the projects goals were aligned with his interests. In the end, a more accurate forecast and a more streamlined process give him more power overall, but he gave up some to expand the pie for everyone.

4.1.3 Cultural

The third perspective of the organization is the cultural lens. This gives insight into how the project relates to, is affected by, or may affect the culture of QWBS. A culture is defined by the norms, values, assumptions, and symbols of an organization. The culture of QWBS partially defined the way the project was approached. The implementation of the improved process also necessitated a slight change in some of the organizational norms.

As was discussed earlier, QWBS was affected by the recession of 2000. This reason was largely used to explain the downturn in the business. This project had a symbolic meaning for the organization. Since all agreed change was needed, for many the project was symbolically seen as a means of getting back on track as a business and getting back to normal operating conditions.

The need for a cross-functional, customer-focused, consensus-based approach to problem solving, as seen in the strategic design and political perspectives, is strongly reinforced by the cultural norms, values, and basic assumptions of QWBS. At QWBS management is by objectives with a great degree of freedom and flexibility given to those doing the job to meet those objectives. With this freedom comes the need for consensus decisions among the stakeholders involved. Without this consensus, those performing the process would be less likely to perform a task the way it is needed and initiatives won't take hold.

One cultural change was needed to successfully implement the improved process. One assumption common for QWBS people is that other employees have much of the same information as themselves. Employees needed to change their assumptions to realize that many times others don't know what they know. Doing this will help employees recognize the need to share their information more often. Throughout the process improvement effort, many were brought to see how they fit into the bigger picture and how their actions affect others. Thinking in those terms is a cultural shift that one manager described as "a huge change for us."

One value of the QWBS culture is the accentuation of the positive aspects of things. People are genuinely excited and positive about their company, job, and life in general. This is a great strength of the culture. Yet, this strength also made confronting hard cross-functional issues more difficult. This point was driven home to me by my supervisor while debriefing about a recent meeting with the VPs of Sales, Finance, and Manufacturing. I was expressing concern that the meeting hadn't gone very well. To which my supervisor replied that he felt the meeting had gone very well and that "just getting those three to admit there is a problem with the process, not just within one area is a huge step." After this I learned to present difficult issues in as positive a light as possible.

4.2 Leading the Change Process

Given the context of the organization as seen through the three lenses, we can now relate the change effort to the Sloan Leadership Model²⁵. Two major aspects of the model describe organizational change processes. The first describes the activity level of the change effort over time, which shows there are several phases of a change effort. The second describes the activities one needs to perform while making change happen. Each of these major aspects will be discussed followed by some reflection upon how I make changes.

4.2.1 Catalyzing Action

The model for catalyzing action describes the organizational change activity level over time during a change effort. This model is best described with the graph in Figure 8 shown below. The model shows three major phases of a change effort. They are, from left to right, building momentum, visionary change, and refinement. Using the framework of each of these phases, this section will describe and analyze the change process as it took place at QWBS.

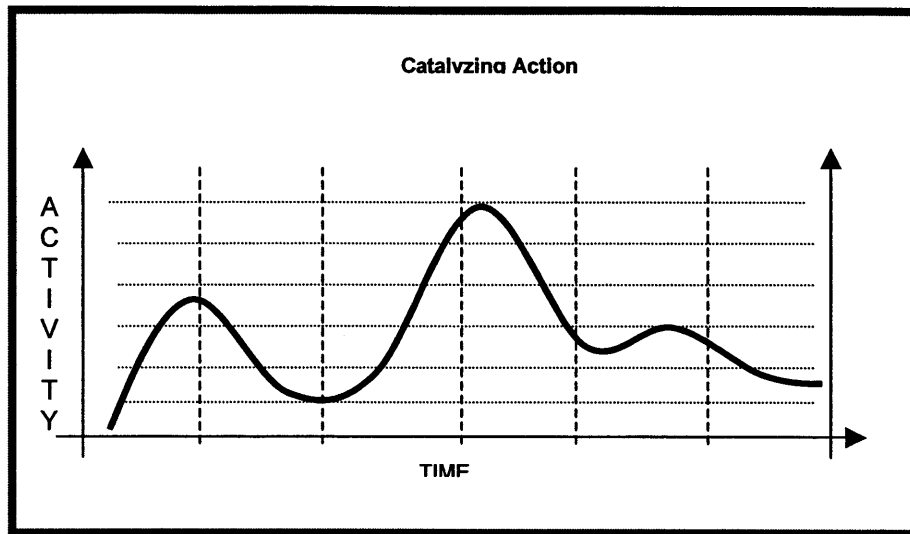


Figure 8 - Sloan Leadership Model

Building Momentum

Building momentum is the first stage of a change effort. In this stage it is important to gain credibility. One of the ways to do this is through what is termed “small wins.” Sometimes these “small wins” come in the form of mini projects or making an impact with a small change. Given the nature of the project, this was difficult to do. I was tasked with providing a holistic vision and framework to improve the forecasting process. Implementing any small pieces of the framework was deemed by management as either a less valuable use of time or premature. Due to the circumstances, I had to build credibility in other ways. The main way I found to do this was through listening well to others and accurately reflecting back to them what I had learned. Another way I built credibility and trust was by ensuring my intentions were to gain improvements for all the stakeholders and not just one area. In tactical terms, this stage spanned the time while I was documenting and finding issues with the process, as it existed when I arrived.

Visionary Change

Visionary change is the second stage and is where most of the action is. Tactically, this was when we were developing and selling the new improved process. While doing this it was important to remember the insights gained from looking through the three lenses. Through these

insights, an improved process was developed that everyone was able to buy into and be happy that it was helping him or her to do better. Going through it was not easy. At one point, before going into a meeting to sell the new process, my supervisor told me, “You’re going to have to hit a home run, or this project is going to go nowhere.” Fortunately, I was able to perform and the changes were accepted for implementation consideration.

Refinement

Refinement is the third stage of a change effort. Tactically, it was part of the implementation phase. After the framework for improving the forecasting process was approved, it needed to be implemented. To implement the recommendations eight process improvement teams were formed to work on the various aspects. I was able to work briefly with a few of these teams in order to share the vision for an improved forecasting process. The majority of this time was spent on knowledge transfer with the forecasting manager who was tasked with overseeing the implementation phase.

4.2.2 Key Functions

There are four key functions or activities that help to make change happen. These are sensemaking, relating, visioning, and inventing. An analysis follows of my experience with these four functions and the consequences of my efforts to carry out each of these activities in the leadership model.

Sensemaking

Sensemaking is discovering an organization. It is an important first step but also continues since situations tend to be dynamic. To discover the organization most of my information was gathered through interviews and meetings. I then tried to organize the data into process flow charts and text describing the process. This was all refined through more interviews and meetings. The first two months of the internship were spent going through this cycle until I came to a good understanding of the forecasting process as it was and the issues hindering the best performance.

Relating

Relating, as the name suggests, is how you interact with the organization. This activity was done, and must be done, continually in order to be effective. To relate well I had to be curious, ask questions, and help people to feel that I needed their input and information. This part was

easy, in that I could not have made any significant improvements without a good picture of the current state. Another aspect of relating well was advocating my own ideas to the right people. This proved a challenge to me. I was not always viewed as being excited about what I said, which in QWBS's positive culture did not come across well. I learned to show excitement, which helped others accept my ideas more readily. Knowing where the power is and focusing efforts in those areas was also important to relating effectively. Looking at the organization through the political lens was helpful in this regard.

Visioning

Visioning is the act of communicating a picture of the future of the organization and building a desire in others to achieve that vision. Doing this was a huge part of the project and is closely linked with how I related to the organization. By using the three lenses and relating in ways that would be received well in the organization I was able to build support for the improved forecasting process.

Inventing

Inventing was the activity of developing an improved forecasting process. This turned out to be relatively easy compared to the other three functions. Once there was a clear picture of the process and the problems, seeing ways to improve the process flowed naturally. Selling and getting others to buy into the improved process was more difficult.

4.2.3 My Change Signature

Another important aspect of the Sloan Leadership Model is that everyone has his or her own personal change signature. The experience of this change effort taught me about my own way of changing things. I learned that I enjoy being creative and inventive when developing changes. I learned that I like to work in teams and blend team members' varied perspectives to form a team perspective. I also realized that I need to improve my relating skills in group settings in order to help things go more smoothly.

4.3 Results

Speaking about leadership and change is great, but it doesn't mean a thing unless there is concrete action taken as a result of the effort. There are two ways one can evaluate the results. First is to measure the outcome against the metrics most important to its key stakeholders. Second is to measure the effectiveness of the change effort itself along several dimensions.

4.3.1 Metrics important to QWBS

The metrics most important to QWBS, according to my supervisor, are cost, quality and delivery. Evaluating the project in this way shows positive results. The cost of the forecasting process will be less due to reductions in expediting and a reduced need for meetings. Some of the cost savings are hard to quantify. For instance, how do you quantify the cost of better coordination or the effect of increased accuracy throughout the supply chain? The quality of the forecast was increased through improvements in accuracy. The quality of the use of forecasts was improved through linking safety stocks to forecast accuracy. Delivery of the forecast was improved by discovering the need of the user to know how accurate it is. All of these improvements are important to QWBS and make the project a success.

4.3.2 Effectiveness of the Change Effort

A second way to evaluate project success is to measure the effectiveness of the change process itself. The key metrics in determining this are how well the findings were accepted, was there implementation and follow-through, are the changes sustainable, was there organizational learning as a result of the project, and was this learning diffused to other units in the organization. This project was successful on all of these dimensions except the final one.

Acceptance of Findings

QWBS accepted my findings and recommendations and considered them further for implementation. The cross-functional team working on the project helped to craft the recommendations. My impression was that the VPs of Finance, Manufacturing and Sales accepted the recommendations and were excited to implement them. On this dimension the project can be viewed as a success.

Implementation

Once the recommendations were approved the implementation began. Eight process improvement teams were chartered to further consider and implement the recommendations. Completing implementation of these changes is a large portion of several employees' objectives. The implementation process was scheduled to be completed early in 2003. On this dimension the project is a success.

Sustainability of Changes

Once the recommendations are implemented they are a permanent part of the forecast creation and use process. While it is possible for an organization to fall back into its old ways, this seems unlikely at QWBS. Management and the forecasting department have more changes planned to expand the scope of the department. All indications suggest that the project is a success on this dimension.

Organizational Learning

The process used to improve forecasting was inclusive of many functions in the organization. Through meetings and investigation there was significant learning that took place. Learning was both technical (i.e. along the lines of the changes suggested) and cultural (i.e. an awareness of where each fits and their affects on others). On this dimension the project seems to be a success.

Diffusion of Learning

This project was solely based in QWBS. There was no interaction with other divisions of Qualcomm. While diffusion of this learning did not occur during my time at QWBS, it remains to be seen if these philosophies will become pervasive throughout Qualcomm.

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5 CONCLUSION AND RECOMMENDATIONS

The process for creating and using forecasts has been improved. In some areas the improvements are significant and measurable. In other areas the effects of the changes will be seen over time. This thesis focused on a specific application of principals, which can be applied to a broad range of settings. While significant improvements have been made, there are ways to further improve the forecasting process at QWBS.

5.1 An Improved Process

The results of this effort can be summed up simply. QWBS now has a shared vision of the future state of forecasting within the organization. The creation of forecasts, their use, and the processes of communication have all been improved in several ways. The sales organization now has guidelines for the use of the CRM software, enabling more reliable customer data. The output of the forecast meets the needs of the user and history is effectively used to improve accuracy an average of 10% to 20%. The whole organization now knows the accuracy of monthly forecasts and has tools to prepare for the demand uncertainty. A process has been defined for communication of changes and the tough decisions associated with those changes. On all fronts this effort can be called a success.

For those embarking on similar change efforts it is important to remember a few bits of sage advice. Listen first and talk second. This is the only way I know to build the trust needed to discover the true state of things. Second, be willing to forego credit for the good of the cause. While many ideas came initially from me, by giving them to the group they grew to become something better. Finally, trust yourself and believe in your ideas. No one will do anything for you if you don't believe in yourself.

5.2 Further Improvement is Possible

There are other changes that may improve the forecast creation and use process further. These recommendations are QWBS centric but can also be applied in other settings as well. A few of these are shaping demand, aligning incentives, and expanding the role of forecasting.

5.2.1 Try Shaping Demand

QWBS experiences month end, quarter end, and year end demand spikes (a.k.a. demand hockey stick). The hockey stick demand pattern is a large contributor to the level of demand variability. As was shown earlier, less variable demand is easier to forecast. The concept of risk pooling was one way used to decrease the variability of demand. Another way to decrease the variability is to actively influence or shape the pattern of demand.

In order to influence the pattern of demand it is important to know if there is any relationship between actions a company takes and the demand pattern it experiences. A study performed at Dell found that sales quotas and incentives drove quarterly demand hockey sticks.²⁶ At QWBS sales force performance is mainly measured based on monthly, quarterly, and yearly quotas. Another QWBS practice contributing to the demand hockey stick is setting up system price quotes to expire at the end of a quarter.

Smoothed demand patterns help forecasting demand be more accurate. There will also be significant impacts on the factory and supply chain, which should result in a lower product cost. Recently, QWBS was encouraged to account for revenue per the guidelines of SEC Staff Accounting Bulletin 101 (SAB 101).²⁷ According to SAB 101, revenue, costs, and profits from the sale of a product with a bundled service must be recognized over the life of the product. With this being the case, it makes sense to have smooth demand and not spend extra money to make shipments to meet an arbitrary deadline.

How can demand be smoothed? To remedy the situation at Dell, the study recommended modifications to the incentive structure of the sales force, encouraging demand matched to the optimal quarterly factory load. This is applicable at QWBS as well. To adjust the sales organizations incentives to reward smoother demand, one possible addition is to add a part to the incentive structure measuring weekly or bi-monthly quotas. Another possibility is to add a bonus for having demand spread evenly across a month or quarter if volume targets are met. In addition, changing the system price quote procedure so they don't expire at the end of quarters or years will help smooth demand. A possible alternative to this is to have a price quote good for a certain number of days. It is very important to not make incentive changes that will encourage smooth demand over serving the customer. QWBS has always been responsive to customer needs. That strength should not be sacrificed.

5.2.2 Alignment of Incentives

The previous section suggested a few changes to the sales force incentive structure aimed at smoothing demand. The saying, “you get what you pay for,” and the related corollary “what is measured, improves” are definitely true in business settings. People behave in accordance with their rewards. Thus, modification of all parties’ incentives to bring them into alignment will provide further improvement to process performance.

Care must be taken though to reward the behaviors that are desired. One example of this is seen in the procurement department. If you ask buyers how their performance is measured, they will tell you they focus on lowering inventory levels. Their management will say that isn’t how they are measured. When confronted, the buyer will then question why they must report and defend their inventory levels in a meeting every month. A change in the focus of those meetings to inventory targets based on demand variability and forecast accuracy will elicit the desired behavior (i.e. to have the right level of inventory to support customer need). Small changes to rewards, incentives, or metrics can lead to big changes in behavior.

5.2.3 Expand Forecasting Department’s Role

The role of the forecasting department has expanded in the improved process. Previously it was a consolidator of numbers for monthly forecasts. Now QWBS is able to leverage the analytic skills in the department to proactively generate forecasts. While this work only focused on monthly forecasts, this same theme should be followed when improving the processes used to generate longer-term forecasts. In an expanded role, the forecasting department could actively participate in creating longer-term forecasts by providing analytical and statistical support. Their role could also be that of an impartial judge on the numbers to provide an outside eye and sanity check. This change will help these other forecasts at QWBS be less subjective and founded on models and/or data.

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