

FORECASTING FROM THE CENTER OF THE SUPPLY CHAIN

By Charles Bonomo

Knowing which products to forecast and when to keep safety stock is a critical component of managing customer and supplier risk in a supply chain ... key ingredients of successful forecasting at Arrow Electronics are aggregation, risk management, collaboration, process and technology ... very often patterns emerge when demand data of different customers are aggregated.

Arrow Electronics was founded in 1935 as a retailer of RCA vacuum tubes and connectors for radios. We started with a storefront on Radio Row, right in the heart of New York City. Today we are the world's largest distributor of electronic components and computer products, and a leading provider of services to the electronics industry, with over 10 billion dollars in annual sales and 12,000 employees worldwide.

Design services, materials planning, inventory management, programming and assembly services, and a comprehensive suite of online supply chain tools highlight the range of our services. Our mission is to represent our chosen suppliers by assisting our customers in the design, manufacture, and use of electronic products from concept through production – globally and profitably.

ARROW'S BUSINESS ENVIRONMENT

Arrow sits in the center of the supply chain with more than 600 suppliers on one side and 175,000 original equipment manufacturers, contract manufacturers, and

value-added resellers on the other. Our link in the supply chain encompasses more than 200 sales facilities and 17 distribution centers in 40 countries and territories. We distribute more than one million different components. We purchase more than 1 billion dollars in parts monthly, and our systems handle over 10.5 million transactions per day globally. The world that we forecast in is truly vast.

As we continue to move through the



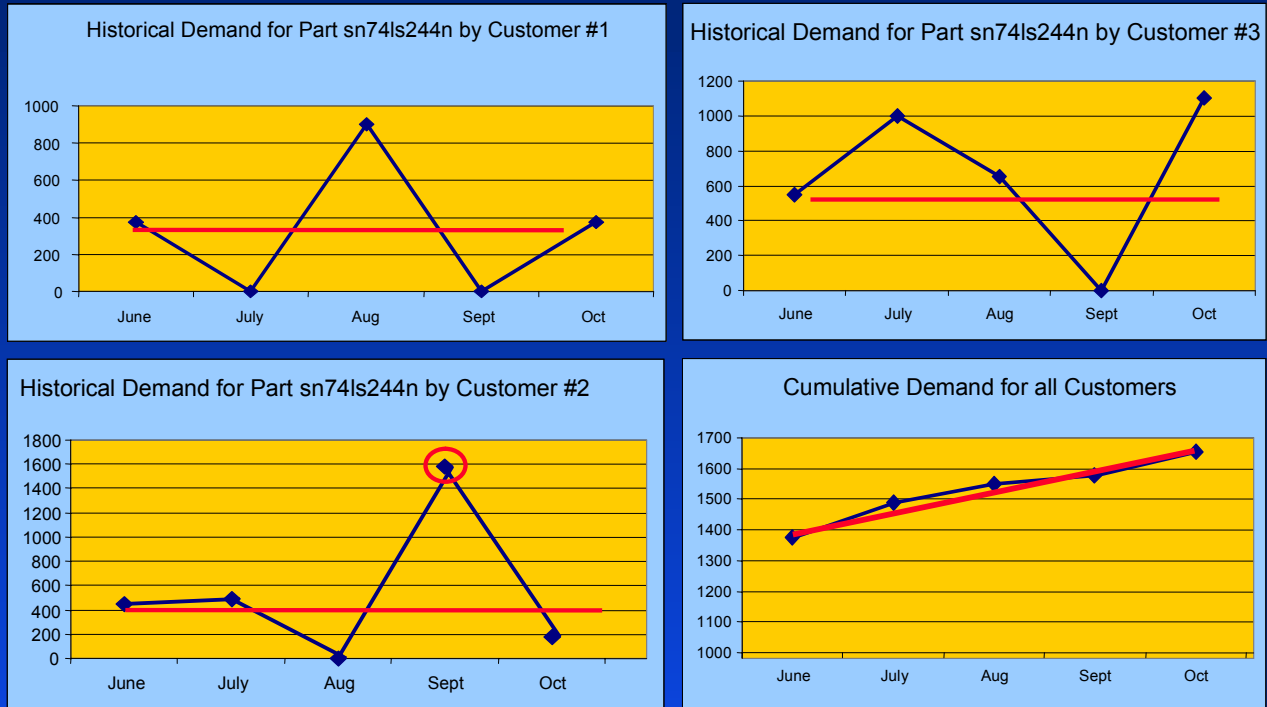
CHARLES BONOMO

Mr. Bonomo is the Vice President of Strategic Programs at Arrow Electronics. He is responsible for managing Arrow's strategic programs, including the redesign of their Inventory Management business around processes and technology. Prior to joining Arrow, he was the CIO at the NYU Health System. Before that, he worked on Wall St. for J. P. Morgan and also spent three years as the Head of Technology in their Zurich, Switzerland office.

world of high-tech distribution, we experience a great diversity in all of the parameters that are important drivers of our accurate forecasting. We are not fortunate enough to be able to define the business terms by which our suppliers interact with us. We deal with countless rules that disable our ability to change or cancel orders anywhere from 43 weeks in advance on the most unforgiving side, down to anytime prior to shipment. Our lead-times, aside from being very inaccurate, vary from 1 to 43 weeks. Lead-times are obviously very important in calculating things like safety stock levels, so we have developed other ways to manage the inaccuracy issue. The products that we forecast also have very diverse selling prices that range from well under a penny to more than \$9,000 per unit. The varied nature of our environment does not end there. In any given month, over 13,000 new part numbers are added to our system. With so many variables having such a wide range of possible values, the world that we forecast in has great diversity.

All business environments contain risk. A business environment with little risk typically yields very small opportunity for reward. In the center of the supply chain, risk comes from many places. While the rewards can be great, mismanaging the risks that you take will result in disaster. Much of our inventory presents enough risk to render traditional forecasting techniques ineffective. However, through processes that combine the precision of a computer system with the practical experience of our forecasting experts, we are able to achieve high levels of procurement automation on almost a third of our inventory. For us, knowing which segments of the inventory to forecast is a

EXHIBIT 1 AGGREGATION – THE MAIN INGREDIENT



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critical component of our asset management process.

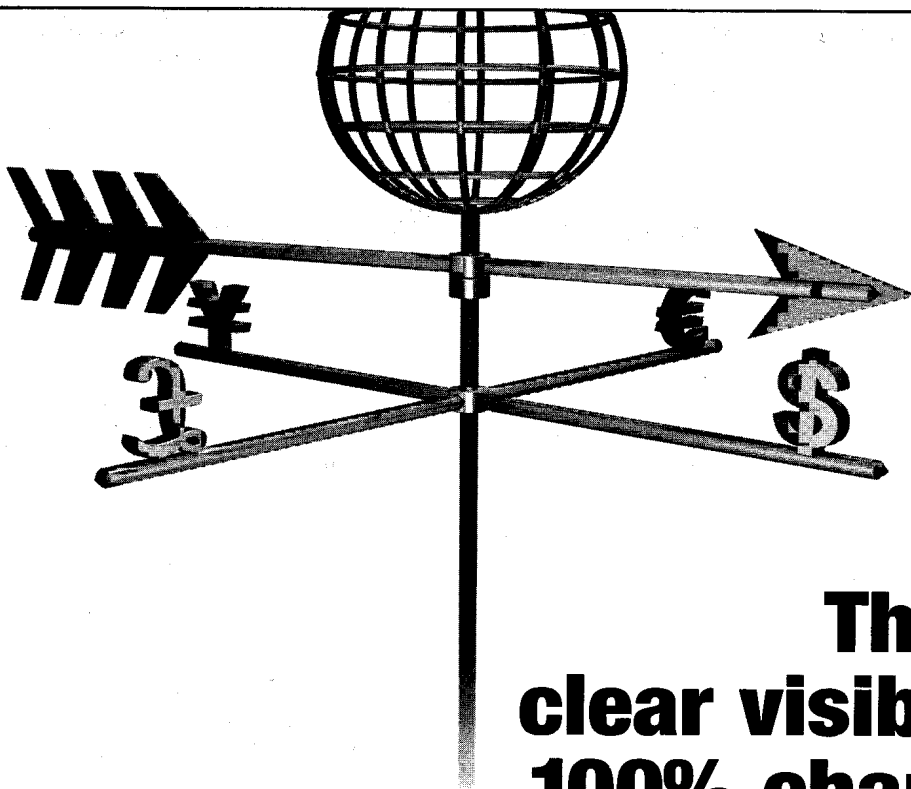
One of the original reasons for the existence of distribution was to buffer product in the supply chain. We buffer a huge amount of inventory, typically purchasing over one billion dollars worth each month. We own this inventory. However, in our world, product risk poses one of our greatest challenges. If you think of this in terms of a financial analogy, each month, we purchase one billion dollars worth of futures contracts on some very risky commodities. We're speculating on things like demand, shelf life, product availability, and other external events that we may have little to no advance warning on, like the more than 26,000 product change notifications that we receive each

month from the Original Equipment Manufacturers.

What is the nature of the customer risk associated with our commodity? Almost 90% of the parts that we sell have less than 5 customers. Over half of the parts that we sell have one customer. For that half of the inventory, sludge is an inevitable fact. It is not a question of "if the customer goes away," it is a certainty of "when the customer goes away. As you can imagine, knowing which products to forecast and when to keep safety stock is a critical component of managing customer and supplier risk in the center of the supply chain.

Regarding the uniqueness of the events that occur in the world of high tech

distribution, it is important to understand two facts of life: Industry Cycles and Product Evolution. We know that these things are inevitable, but without a crystal ball we will never know when or to what extent. One might say that this is no different than the industry that they are in. All markets cycle and all products evolve. However, all things are not created equally. In our world, an industry cycle is typically accompanied by a cycle in our revenues, swinging 40% in either direction of the mean. Additionally, the rate of change associated with high tech products is second to none. A new product can be introduced with short notice and literally stop all sales on a product that we have been stocking for a decade; or a new product might be introduced with great expectations only to be made obsolete by a newer technology a



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few weeks later. Think about how PC buying decisions are affected each time a next generation microprocessor is announced.

CORPORATE AND CUSTOMER FORECASTS

Using the world that I just described as a backdrop, let us now describe how we forecast at Arrow and why it is important. We break forecasts into two segments: the forecasts that we generate internally to support our traditional customer relationships, which we call 'Corporate Forecasts.' And the forecasts that our customers provide in support of our more complex supply chain operation; we call them 'Customer Forecasts.' Both of these information sources play a key role in influencing our purchasing actions.

So, what are the important elements of forecasting from the center of the supply chain? Unfortunately, there are too many to discuss. I'll focus on the four most important ingredients: Aggregation, Risk Management, Collaboration, and Process and Technology. If you're fast on your feet, you might say, "Hey that's 5 ingredients." My response is that you're right, but technology and process go hand in hand, so I didn't break them apart.

AGGREGATION: THE MAIN INGREDIENT

I don't want to leave the impression that there are no advantages of being in the center of the supply chain. We have the unique opportunity to aggregate demand and spot clear trends where none appear to exist. In other words, when we aggregate the data of different customers, trend begins to emerge. (See Exhibit 1) Let's use a simple example to demonstrate how aggregation helps us to forecast at Arrow.

In Exhibit 1, Customer No. 1 is a very typical customer, but its sales data reveals high demand variability. Unfortunately, variability is all that is apparent to our system when analyzing demand for the SN74LS244N at this very granular level. Our system analyzes the sales history and

is unable to spot a trend. The resulting forecast is a single term model, which means that a straight line or flat demand stream is anticipated. A single term model only exhibits a level. The concepts of trend and cycles are absent. Mathematically, a single term model is represented by $y = c1$. This equation yields a flat line with no trend.

In the same exhibit, the sales pattern of Customer No. 2 is also quite common but it has a little less variability with the exception of September. Because of the sparseness of data at this level, and the limits we have configured into our system, September will be treated as an outlier. As such, the system would filter out the sales of this month to determine the trend for this customer. So, again, in this case, when a single term forecast model is utilized, flat demand is projected. In case of Customer No. 3, we also have a very sporadic demand. When data are analyzed in isolation, our system won't distinguish any significant upward or downward trend in buying patterns. Here again when a single term model for forecast is used, flat demand will be expected.

However, when we cumulate (or aggregate) demand for the same part across all three customers for the same time period, a clear-cut trend emerges. The trend was not apparent at the most granular individual customer level, but it is very pronounced when the sales history is aggregated for multiple customers. At the aggregated level, our system recognizes the upward trend and uses a two-term model to generate a forecast reflective of the increasing demand. A two-term model exhibits a level and a trend. The concept of cycles is absent. Mathematically, a two term model is represented by $y = c1 + c2t$ where t is time. This equation yields both a level ($c1 = y$ when $t = 0$) and a trend ($c2$).

Our models do not typically display cyclical customer buying patterns, as seasonality, weather and other regularly reoccurring phenomena, as they do not have a noticeable impact on our sales. Our cycles are reflective of the entire industry and occur over very long periods of time.

Our forecasts do not reflect industry cycles.

Although the concept of aggregation is very basic, it plays a very important role in our supply chain management. Furthermore, we can extend this concept to product families and spot a move to or from a particular technology. We can apply it to all parts that a customer buys, and get an early warning signal that they are decreasing production. We can also use customer level aggregation to spot a trend even before it is reflected in their forecasts. We can also apply aggregation to an entire business segment to determine whether or not something unusual is likely to happen. The advantages of aggregation are abundant in the center of the supply chain.

RISK MANAGEMENT

How we manage risk is another key element of our success. Globally, Arrow drives hundreds of thousands of purchase transactions each day. We see a large cross section of the entire high-tech supply chain. The cross section that we view is significant enough to provide a very accurate representation of the entire high-tech supply chain. Our ability to anticipate risk is derived from our unique and comprehensive view of the market.

Speed and timing are important elements of our forecasting process. Under normal circumstances our process follows a very structured path. However, some of the events that I described earlier are substantial enough to call for immediate adjustment to our forecasting strategy. Real time recognition of changes in things like lead-time, product lifecycle, and breadth of customer usage are all at the fingertips of our forecasting specialists. When a significant event occurs, our processes allow us to reconsider the accuracy of our forecasts or even decide if we are still comfortable with having any forecast at all. We have the ability to make these decisions in real time.

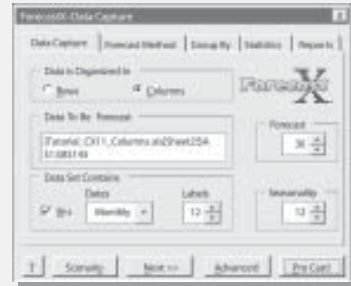
We use one of our commercially available products, Arrow Alert, to help drive our own forecasting performance. I don't want this to sound like a commercial

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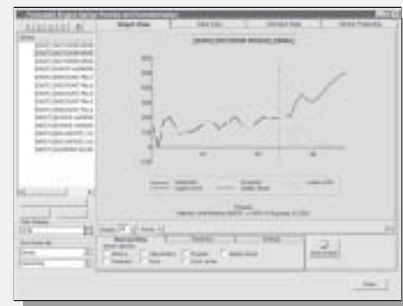
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- Central Database for Your Planners
- Control Your Product Lifecycles



Forecast X Collaborator

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- Enhance Your Bottom Line with Collaborative Forecasting
- Gather Valuable Feedback from Your Salespeople, Customers and Suppliers



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for any of our tools, but I think the explanation of how we're using real time information is something that you may be able to apply to your own forecasting practices.

Arrow Alert monitors, configures and sends alerts to forecasting specialists for particular product segments that they manage. Forecasting for all products occur at regular frequencies, which, I believe, is the same for many other businesses. However, whether it is daily, weekly, monthly or yearly is not as important as your ability to adapt and change your process, based upon significant, unplanned events that occur. We are especially sensitive to things like end-of-life notices where a last time buy date may not provide a lot of time to adjust our forecasts up or down, or a significant change in lead-time where safety stock may need to be adjusted immediately. Actually, there are countless alerts that may trigger the need to adjust our forecasts for a particular part or technology. Our ability to react to these alerts in a timely fashion has a dramatic impact on the quality of our forecasts and performance of our inventory. Each morning our specialists are alerted to any significant changes in a product's risk profile, lifecycle, manufacturing, or even form and fit.

The alerts come to them as an email message. The information is filtered so that the specialist only sees information on the parts he or she manages. It is also sorted and prioritized according to the risk that the change presents. Depending upon the severity of the risk, they will take immediate actions such as re-forecasting, recalculating safety stock or changing existing supplier orders. The prescribed action for a given Alert is driven by a combination of automation via integration with our forecasting system, and workflow management, which is clearly laid out in all of our training material. At the center of the supply chain, early detection and quick response to many types of risk is essential.

COLLABORATION

As I mentioned earlier, there are two

types of forecasts that we utilize at Arrow — Corporate and Customer. Most of what I have discussed so far has been specific to corporate forecasts. Let's take a few moments to think about customer forecasts and the advantages and risks that they bring. On one hand, there should be no more accurate picture of future demand than a customer's forecasts. On the other hand, predictions of future demand sent by our customers are often very inaccurate. Arrow Collaborator is a tool that we offer to our customers as service to provide greater visibility into their specific link in the supply chain with Arrow.

The Supply Demand Imbalance screen in the Collaborator tool allows our customers to spot shortages and excesses in inventory that is specifically reserved for them, over the next four weeks. Through daily updates, the customer can see where their forecasts outweigh or undercut the inventory they have asked us to reserve for them. In this screen green up arrow indicates where we will meet their projected demand and the red down arrow shows a potential shortage. If there's a shortage, our system checks our publicly available inventory and indicates whether their demand can be covered. If we still have a shortage condition, the days of supply are calculated and the date of the first potential shortage is displayed for the customer. We also give our customers the reasons for the shortage on this page. As you might imagine, this is a very powerful and popular feature of the tool.

The Part Status Page of the Collaborator tool provides immediate notification when a customer's forecasted parts change from a standard or active life cycle status to one that has an associated liability. If a customer asks us to hold high-risk inventory specifically for their use, we typically require them to sign a contractual agreement to pay for any unused quantities that we order on their behalf. This report actually gives the customer a "heads-up," where we let them know as soon as we receive a Part Change Notice (PCN) from the supplier. From the time of the status change, our suppliers usually give us a 30-day period to return any unused inventory.

This page shows the customer all of the parts on their forecast that have changed from an "active" status to a liability-associated status since we received their last forecast. The value of the parts, which is the price we charge the customer for the part, times the total quantity forecasted, is the financial liability that will be incurred by the customer unless we take quick action to return the parts and find an active replacement. Naturally, the customer has the option of using the devices, which means that no action is necessary.

We also allow the customer to "drill down" to get more detail about the parts in question. A Part Status column tells the customer what the specific lifecycle status is for each new liability-associated part. A Forecast Value column displays the customer's price, times the quantity forecasted on a part-by-part basis. This page is a powerful collaborative tool that Arrow and its customers use to monitor and mitigate financial risk.

The Forecast Response page graphically depicts Arrow's current ability to cover a customer's forecasted requirements over a six-month horizon. We show the customer their six-month forecast on a month by month basis and then we color-code our ability to cover their needs with reserved, publicly available, and on-order inventory. This data gives our customers complete and comprehensive supply chain information, all of which can be uploaded into their MRP system to perform "what if" analysis. By using this data, our customers can easily determine if Arrow can cover their needs, if they decide to pull in production on a certain product.

A "color legend" pop-up indicates what each of the colors means. On this page, green is good and red is bad. The darkest green means that the customer already owns the parts; medium green means we have the parts on reserve for the customer; bright green means the parts are in our public stock and available for all customers. Yellow or caution means we don't have the parts in stock, but we have placed an order with our suppliers and they

should be on hand in time to meet their forecasted requirements. Red means that we don't have the parts, and our suppliers have confirmed that we will not have them in time to meet their needs.

A color bar is used to give our customers an easy to read visual summary of their risk. If the color bar shows two or more colors in a given month, it indicates partial coverage. If you were using this tool on-line, you could roll your mouse pointer over the forecasted quantity and another drop down menu would appear to break down the covered quantity by category. For example, of the 100 parts you forecasted for the month, 25 are on reserve, 50 are in public inventory, and 25 are due in from the supplier. The Forecast Response page gives the customer a complete visibility to their supply chain in one quick snapshot.

TECHNOLOGY AND PROCESS

There are two overriding concepts that act as catalysts for the things I've discussed, they are: Technology and Process. While the concept of utilizing technology for the benefit of more accurate forecasting is fairly straightforward, the definition of what process is warrants some further explanation. Process is the formalization of how people complete a certain routine aspect of their job. It can also be thought of as Workflow Management. I will come back to process in a moment, but first I would like to explain a bit more about the technology that helps us to drive one of the most complex supply chains in the world.

We have made a huge investment in technology, and use not only the tools that we have developed internally and make available to our customers, but also best of breed products from companies like Manugistics and Sun. Arrow's investment in these technologies began over 4 years ago with the development of tools and services that were marketed specifically to our customers. Today we have also found great benefit in using these tools to drive our internal processes.

We maintain the most comprehensive

database of product information in the industry — Ubiquidata. Ubiquidata contains up to date information on over 16 million parts. By adding technical information to our commerce data, customers can see all dimensions of a part for both our franchised and non-franchised suppliers. Ubiquidata is also the database that drives many of the tools that are utilized in our inventory management processes. Arrow Risk Manager, Alert and Collaborator all derive the part related data from Ubiquidata. Data elements relating to technical parameters, risk, availability and lifecycle are all accessed via Ubiquidata. Arrow's inventory management process would not be possible without the technology that I've just described.

Workflow management taught and reinforced until it feels like religion, is key to our success. I refrained from calling workflow management training, as training is only one small part of changing behavior. Successfully managing inventory from the center of the supply chain requires discipline and expertise. With the volume of inventory that we manage, there is no way around placing huge purchasing decisions in the hands of many individuals. Our best practice is to make sure we always provide the guardrails that are necessary to guide our specialists down the correct path. Every exception that can occur within our Inventory Management process is documented and referred to a specialist in a prescribed workflow format. Each workflow shows the specialist how to solve a particular problem, he or she is faced with, through a combination of collaborative or system based activities. Predictable behaviors consistently produce predictable results.

BENEFITS ACCRUED

In the end, it may be important to mention some of the benefits that are accruing by managing our supply chain this way. They are resulting primarily from our ability to speculate effectively because we have now a fairly comprehensive view of the market. The two key benefits are:

One, we're able to use forecast data to



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determine when prices are firming and when availability is tightening. In today's market, customers are very comfortable in placing book-ship orders, which allow them to exploit pricing opportunities at the risk of product availability. In other words, because product is generally available, customers wait until the last minute to order and obtain the best price. When we begin to see an increase in planned orders and customer forecasts, it signals that supply is tightening, which allows us to make strategic decisions regarding things like pricing, lead-time, safety stock and forecast levels.

Two, we have an early indication of whether the lead-times are increasing or decreasing. When we observe that the ratio between our receipt activities and open purchase orders is decreasing, it means that the lead-time is increasing. In other words, if we are placing orders faster than products are arriving, lead-times are increasing. This signals us to firm our prices, and adjust our safety stock levels and corporate forecasts. These are just two benefits that have resulted from the rich data that is now available at the center of our supply chain.

Hopefully, this article provides some valuable insights into the complex world of high-tech distribution and gives a greater appreciation for our daily challenges. In a world, as vast, complex and dynamic as ours, the proper exploitation of forecasting tools and our ability to react quickly to change are essential to our success. ■