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Other

IBM Research Report

IBM Express Services for Inventory Management - with SAP

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White Paper

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IBM Express Services for Inventory Management – with SAP

A low cost inventory management alternative for quick implementation

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Executive Summary

IBM's Express Inventory Management offering, leveraging SAP's Business Warehouse functionality, is one of the quickest payback solutions provided by Business Consulting Services. Reducing a client's inventory asset investment and associated operating costs is central to the offering. The solution entails building inventory target-setting algorithms and performance reporting within SAP BW – creating an efficient, repeatable, and intelligent process for reducing and managing inventory levels. The award-winning quantitative supply chain management expertise of IBM's Research Labs and Integrated Supply Chain team are incorporated into the solution toolkit. Clients who already own SAP BW will require no additional software investment. Clients considering investing in SAP BW likely can justify their entire SAP BW investment from the savings afforded by the Inventory Optimization Solution. A recent client achieved a 13% inventory level reduction within a short amount of time.

Introduction

One of the most tangible ways companies can benefit from IT investments is through implementing solutions that provide inventory reduction opportunities. Three of the most important ways companies can reduce their inventory are:

1. More accurate & faster receipt of demand information
2. More reliable & shorter supply lead times
3. Better inventory policies

Faster receipt of demand information and shorter lead times can be achieved by changing planning processes, modifying supply chain infrastructure, and adopting best practices that enable rapid flow of information on both the demand and supply sides. SCM solutions are designed to support these activities. Leading demand planning solutions can also help increase the accuracy of demand forecasts. This, in turn, reduces the need for safety stock which and its impact on a company's bottom line. Improved supply reliability has a similar impact on inventory levels.

On the other hand, no matter how well the planning processes are executed, and how advanced they may be, there is almost always some uncertainty left in a typical supply chain both on the demand side and the supply side. Companies still have a need for inventory policies that fit their supply chain environment and protect them against the serious consequences of these uncertainties.

Challenge with Inventory Optimization Solutions

Analytical inventory optimization is an essential element of competitive supply chain management practices. While traditional SCM solutions have a process focus, their ability to provide advanced inventory optimization has been limited. This has resulted in the birth of several software products that focus on inventory optimization. They can be used in concert with APS or SCM solutions in order to fill the gap. However, one needs to be cautious about a number of things when considering use of such software:

- **Fit to need:**
  Canned inventory optimization solutions are usually designed to handle limited classes of inventory problems, and they present viable options when they fit well to the problem at hand. However, because they are designed to handle the most common planning situations, they may have difficulty addressing certain characteristics of a company's supply chain that are not common and therefore do not fit well to the assumptions. The areas where the assumptions can breakdown include non-typical customer service definitions, complex capacity constraints, complex lot sizing rules, unusual or sporadic demand patterns, and product characteristics such as newly launched products, short shelf lives, promotions, etc. Any unusual characteristics that violate the underlying algorithmic assumptions can hinder the effectiveness and therefore the potential benefits of canned solutions.

- **Software proliferation:**
  In order to gain full benefit of a well planned and executed supply chain process, companies find themselves in a situation where they need to buy several layers of software. Typically their ERP system is at the bottom layer; then there may be systems that are integrated to ERP. These include DRP, MRP, Demand Planning, Supply Chain Management, Order Fulfillment, Procurement Planning, Inventory Optimization systems etc. These layers of software and systems present a serious IT challenge to companies that are concerned about cost effective management and maintenance of their IT portfolio. Realizing that these costs can be very high, many companies understandably resist additions to their systems portfolio.

- **Cost of implementation:**
  Stand-alone solutions have to address issues such as Internet access infrastructure, security, system integration, etc. This presents itself as an unavoidable infrastructure cost that has to be incurred in order to realize the benefit of the solution - which is essentially inventory reduction and/or customer service improvement. To the extent that a solution can take advantage of existing infrastructure in addressing these issues, it will be more attractive from an implementation and maintenance cost point of view.

- **Systems integration:**
  Since inventory optimization has extensive data requirements, integration to existing ERP and SCM systems can be time consuming and costly. Robust and flexible data extraction templates can significantly reduce system integration costs.

- **Purchase price, maintenance and user fees:**
  Stand-alone software typically requires an upfront purchase cost, annual fees based on the number of users, and maintenance contracts. Version upgrades add to these costs as does training and/or hiring new staff that can use the software effectively.

> *While successful implementation of inventory optimization software is data intensive, the end product of the implementation has pretty much one key output: the optimized inventory policies for each SKU*

Optimized inventory policies are the most important output provided by the inventory optimization software. Often, these policies are characterized by one or two parameters such as safety stock and lot size. One may think you have to do a lot to get very little here; but truly optimal inventory policies can reduce inventory investment and improve customer service significantly. Hence, most of the time, a very attractive business case exists for purchasing and implementing such software. Of course, companies that do not have the execution processes in place for proper implementation of these policies cannot get much use out of these policies. Along with other basics, execution typically requires visibility to different kinds of inventories (such as on hand, on order, committed, in transit, etc.) across the supply chain as well as visibility to demand information such as forecasts and sales orders. Most ERP systems or SCM systems have the capability to provide this visibility, though fragmented systems could pose data integrity problems.

An Alternative Solution

It is fair to say that most of the upfront effort and therefore cost incurred with inventory optimization software comes from data and systems integration. Although the algorithmic part that does the inventory optimization is the part that creates the value, this is relatively inexpensive as many algorithms are readily available in various sources such as text books, hand books, and academic publications. Needless to say there are differences in the power of these algorithms. Some very specialized software companies or companies that have strong research departments can provide proprietary techniques that are not publicly available.

In many cases, relatively simple algorithms may provide satisfactory solutions. Nevertheless, the entire world of available algorithms and techniques is a large and a complex one; it requires special expertise to search the literature and conduct analysis to find the best fit to the problem at hand. In some cases, available algorithms may need to be modified in order to ensure a good fit whereas in some cases, a brand new algorithm may need to be developed. These tasks require highly skilled individuals (typically Ph.D.'s in inventory optimization methods or operations research in general).

An alternative approach to potentially costly implementation of stand-alone inventory optimization solution is to utilize a tool-kit approach. This simply entails the use of a rich library of algorithms that can be made available on a platform already in use. Coupled with data extraction templates ready for deployment, this approach can be very effective in terms of implementation time and cost.

IBM's Express Inventory Management Solution on SAP-BW

The approach that most standalone inventory optimization software packages use may be described as follows: 1) Obtain an extract of data from an ERP system (typically via flat file or Microsoft Excel file); 2) Import into software package and put in a form an optimization engine can use; 3) conduct calculations using a language such a C or C++; 4) Conduct the calculations; and 5) Place the output into a data repository that the user views and can be fed back to the ERP or APS system.

We followed a different approach to make things work more seamlessly for SAP-BW users. Since SAP R/3 is a very common ERP platform, and SAP's Business Warehouse module has strong capability to extract and manipulate data from SAP R/3, it provides a number of advantages for creating a leading edge inventory management capability in a cost effective manner.

IBM Research and Business Consulting Services have successfully implemented this alternative solution for one of the clients providing them 13% inventory reduction benefit in a short amount of time.

We use proprietary formulas that are developed at IBM Research and coded these formulas in BW's query language. This eliminates the need for running computer code outside of the query tool. In other words, everything is done at the query environment making it a truly seamless solution. This also makes it possible to do real time optimization and what if analysis without the use of expensive software and without a need for expensive development efforts.

This approach can solve many of the most common inventory problems. When it comes to special cases, customized algorithms can be coded either in ABAP or a common language such as C or C++ or Java. These algorithms are integrated to the solution at the data extraction level and results are stored into BW info-cubes. Then, BW reports the calculated optimal policies.

Since sales data is accessed and other historical demand statistics are calculated during data extraction from R/3, if advanced forecasting algorithms are desired to do more accurate forecasts, these can be called to run during the data extraction process.

Advantages

So far, we have briefly explained our approach to create a seamless inventory optimization solution for SAP users. Below is a summary of the advantages of this approach.

- **A solution without purchasing additional software:** SAP users do not need to purchase any software as this solution is designed entirely on SAP-BW.

- **Utilization of existing infrastructure:** Since this is a solution provided on BW, there is no need to create new security protocols, network integration infrastructure, and web access protocols. All these are already provided by SAP's infrastructure for SAP users.

- **Ease of data integration:** Custom ETL templates make it easy and pain free to extract transaction data from R/3 in to BW. In addition, other flat file interfaces are available to access data in other applications including legacy systems.

- **Flexible BW reports:** Using strong query capabilities of BW, various reports of optimal policies, KPI projections and "what if" analyses for decision support are created.

- **Minimal business process and IT training:** Since companies that use SAP already have trained staff in SAP and BW, minimal technical training is required in order to use this solution. As for the business process, the solution does not necessarily require changing existing inventory planning processes. It requires that the execution of recommended inventory policies is done properly by monitoring key metrics such as “inventory position”, “sales orders”, etc.

- **Cost of maintenance:** Since this solution requires no new software, typical purchase cost and user fees do not apply. The maintenance costs are minimal as this can be done as a part of the existing SAP maintenance program.

- **Availability of algorithms:** Through its toolkit approach, the solution allows quick custom selection or development of the best algorithm that fits the problem. Standard algorithms as well as algorithms proprietary to IBM are available in the toolkit. The solution design also allows using forecasting algorithms and inventory optimization algorithms in combination to delivery more value to clients.

- **Ability to handle special cases:** Since the design allows integration of customized algorithms, special cases where standard algorithms do not fit can be handled by developing new algorithms or modifying existing ones.

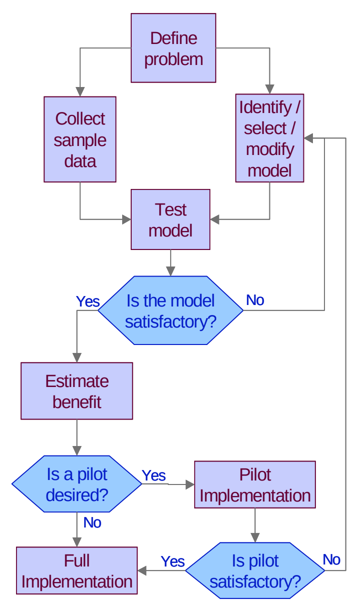
- **Real time what if analysis and reporting:** Inventory managers / analysts can do what if analysis using BW query reports to see how inventory levels are impacted if they change some key factors such as customer service objectives, operating objectives and inventory policy types.

Flexibility of the Approach for Other ERP and Query Platforms

The approach can also be implemented using any other ERP tool as long as data extraction and repository modules are available. As for the front end, since our formulas are designed for generic query languages, any query tool can be used for the user interface and reporting. We chose to do the implementation on BW for the time being, because our current focus is SAP users. We documented the calculations in their generic form, making it feasible to deliver the solution on other ERP platforms.

Solution Development & Implementation Methodology

In the process of developing the best inventory optimization model, we adopted a toolkit approach. The toolkit approach is different from a typical software implementation. First, the inventory model to be implemented has to be selected and tested based on sample data from the client. The model has to fit the client’s environment; it must reflect the objectives, service definitions, demand patterns, and constraints; it must not have assumptions that alter the representation of the actual problem. One of the best ways to see if these are all satisfied is through a simulation test of the model based on actual data. The toolkit has an Excel based Model Selection & Testing (MST) tool capable of conducting these simulations.



Once the model is tested and its performance is satisfactory, it is documented to be coded for the implementation. The method avoids making any assumptions about the problem. If models available in the library do not fit, a custom design of the right model and solution algorithm is done.

In addition to model selection and testing, there can be specific reporting and KPI calculation requirements from the client. Calculation of these KPIs and reporting requirements are also documented prior to implementation.

In the toolkit, there are data extract-transform-load (ETL) modules for gathering transaction level data that are ready to be implemented. If input data needed for implementation have some non-standard items, ETLs have to be developed for those items, and info-cubes have to be generated in BW.

Once all input data extraction templates and reporting requirements are ready, the implementation plan is made.

The implementation consists of applying and testing data extraction templates, inventory optimization calculations and testing of query reports.

Prior to full implementation, a pilot implementation can be conducted and performance can be monitored for a certain period of time if the client desires.

The following table summarizes steps of the methodology.

Overview of Methodology

1. Define problem

- *Interview key business people*
- *Develop understanding of operational environment*
- *Document problem description, assumptions, objectives, constraints and requirements*

2. Select & test inventory optimization model

- *Document data requirements and identify data sources*
- *Collect data for pilot model analysis*
- *Build and test model on sample data*
- *Review results, modify and finalize the model*

3. Make solution architecture

- *Document input and output requirements*
- *Document user functionality requirements*
- *Imbed optimization calculations*
- *Review & finalize solution architecture and related technical details*

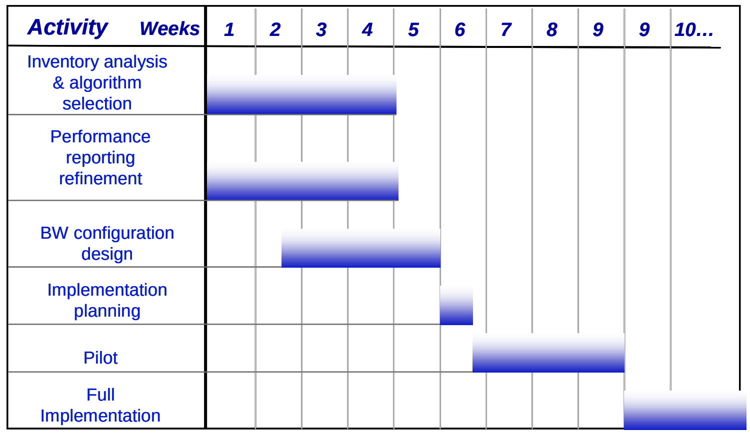
4. Customize SAP-BW data & reports

- *Customize / modify input data variables*
- *Customize / modify calculation of intermediary variables*
- *Customize / modify output data variables*
- *Customize output reports*

5. Start SAP-BW implementation

- Apply and test ETL templates for R/3 data extraction
- Apply and test ETL templates for data extraction from other systems
- Apply and test BW info-cubes
- Apply and test inventory optimization algorithm
- Apply and test BW reports
- Apply and test inventory policy uploads

Implementation



The rationale behind the above methodology is the desire to enable quick and cost effective implementation for the clients. Simplest pilot implementations can be done within 8 to 10 weeks. Of course, the speed of "full" implementation depends on the scope and scale of the implementation and the complexity of the client's supply chain. Since a cost effective pilot can make it possible to observe and document the business benefits, it can provide comfort for full scale implementation decision.

Why A Toolkit Approach?

A large variety of inventory problems attracted a lot of research in modeling and solution since as early as 1950's. Numerous publications in academic literature have resulted in a highly proliferated inventory models. It is hard to come up with a model that can solve a large set of problems accurately. Consequently, each model tends to focus on handling a specific characteristic of a large variety of problems.

One of the main reasons for the proliferation of models is the fact that inventory models have to consider many factors impacting business performance. The following list has some of these factors.

- **Supply Network Characteristics:** Single Plant, Multi-Plant, Single-Echelon, Multi-Echelon, Multi-Mode selection, and Multi-Channel network characteristics all have implications in terms of data, process and algorithm requirements.
- **Industry Characteristics:** Industrial Production, Electronics Assembly, Chemical, Pharma, Auto Assembly, Food, Retail & Distribution, CPG, and Aerospace have all different operational environments that require substantially different models.
- **Cost Characteristics**: Lot sizing rules, Manufacturing fixed and variable costs, Set-up costs, Capacity limitations, Transportation costs, Storage costs, Shortage costs, and Inventory holding costs all have implications in terms of what to optimize and how the optimization has to be done.

- **Process Characteristics**: Periodic or continuous review of inventory, Basestock policies, Basestock & fixed EOQ, Basestock & variable EOQ, One-for-one policies, (S,s) Policies, (S,s,T) Policies, Quantity discounts, etc. all require different inventory policies requiring different optimization algorithms.

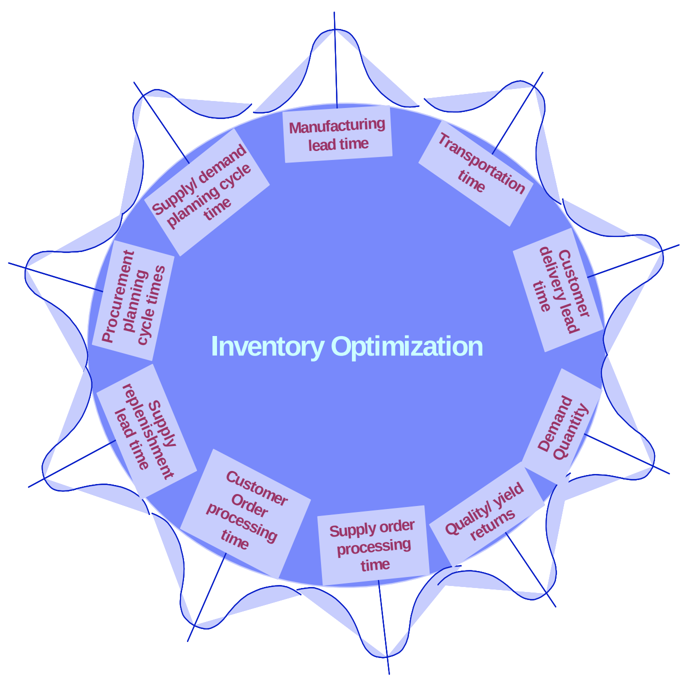
- **Demand Characteristics**: Forecast Error, Daily Demand Fluctuation, Sporadic Demand, Seasonal Demand, Correlated Demand, Statistical Demand Distribution, Order Patterns, Volume Patterns, and Promotion Demand all lead to differences in the math underlying the optimization algorithms.

- **Lead Times:** Planning Lead Times, Replenishment Lead Times, Customer Order Lead Times, Transportation Lead Times, Transshipment Lead Times, Customer Delivery Lead Times, Order Processing Lead Times, and Information Delays lead to different model assumptions.

- **Customer Requirements:** Fill Rate, Probability of No Stock out, On Time Shipment, On Time Arrival, Delivery Lead Times, Volume Flexibility, and Buffer Safety Stocks are all requirements that have implications on how the optimization problem has to be defined.

- **Optimization Objectives:** Minimize inventory, Minimize backlogs, Minimize shipment delays, Meet service target, Maximize profit, Minimize Transportation Costs, and Minimize Set-up costs are all potential objectives that lead to different problems requiring different math.

Formulating all possible options and developing a solution for each option is not easy and is not practical. A flexible solution framework that can easily integrate custom developed models and algorithms is needed. In order to handle a large variety of problems, a toolkit approach makes more sense.

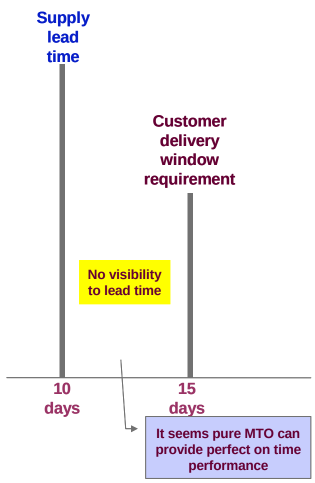


Importance of Uncertainties & Data Collection

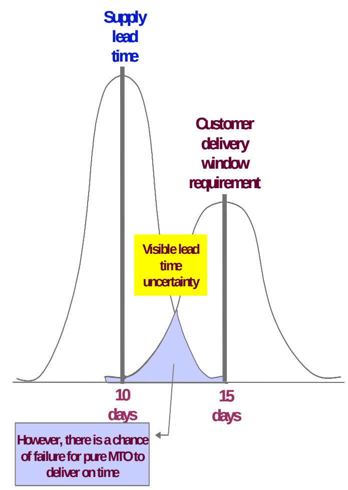
One of the biggest challenges of inventory optimization is that some of the data required to capture the uncertainties in the system may not be available. The sources of uncertainty can be numerous. Two things are very important in handling uncertainties: data collection and algorithmic capability.

In order to capture the impact of the uncertainties properly, historical data have to be collected for all uncertain parameters. Although there are several different sources of uncertainty, we will shortly discuss two of the most important ones.

One of the sources of uncertainty is supply replenishment lead times. These lead times usually exist at the planning level. However, planning level data may not reflect actual performance. Unfortunately, capturing actual lead times is more difficult than using planned lead times. Procurement orders may have to be monitored. Therefore, many companies resort to the easy way and use the planned lead times. The risk of not using actual lead times is that, no matter how advanced, inventory optimization calculations will not be able to account for this uncertainty and therefore recommended safety stocks can be significantly off target either on the upside or downside.



Another source of uncertainty (much less taken in to account) is the customer lead time requirements. Transaction data can show when customers place their orders and when they want delivery. If this data is not used in the inventory optimization, important information that can potentially reduce inventory levels will be missed. Typical service level definitions such as “fill rate” and “probability of no-stock out” do not take advantage of such information.



In some cases, companies may want to implement “replenish to order” or “make-to-order (MTO) policies” if they think customer delivery lead times are longer than supply lead times. However, not all customer orders are the same. Some orders may require quick deliveries, some may not. In such cases, pure MTO policies will not be able to provide adequate service for all orders. Therefore it is essential to capture the order level transaction data in order to understand the details of customer delivery requirements. Of course, a good inventory model should take such data in to account.

Available Inventory Policies

In the current version of the solution, we have made the following inventory policies available in our library.

- Fixed DOS policy
- Inventory minimization with probability of no stock-out target
- Inventory minimization with fill rate target
- Inventory minimization with on-time delivery to request target
- Inventory and backlog cost minimizing policy
- Profit maximizing policy

Most of these policies can be implemented in different inventory management process environments. Depending on the process, they will have different impact on inventory and service. Different versions of these policies are available based on the following processes:

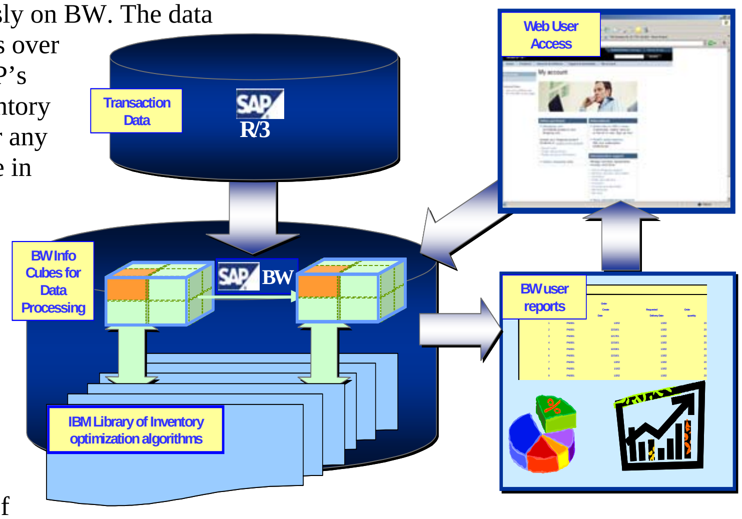
- Periodic review
- Continuous review

In addition, the following lot size options are incorporated in to the policies:

- Fixed lot size
- Optimal lot size
- Variable lot size

In addition, there could be minimum and maximum lot size restrictions. If there are such restrictions, they are treated as constraints on the problem.

Solution Overview from User's Perspective



The solution works seamlessly on BW. The data connection to R/3 and access over the web is done through SAP's network infrastructure. Inventory optimization calculations for any subset of SKU's can be done in near real time.

Analysis

Inventory analysts or managers can conduct various "what-if" analyses that can help them understand the implications of changing service levels, inventory policy parameters and compare various types of inventory policies. Some examples of "what-if" analyses are:

- How much more inventory do I need to hold if customers want no more than 1 day delay in delivery?
- How much more inventory do I need to hold if acceptable customer delivery windows shrink by 3 days?
- How much can I save in inventory if I shift my inventory policy from "fill rate" to "on time delivery" to request?
- How much can I save in inventory if I change my inventory policy from "on time delivery to request" to "on time delivery to commit"?
- Customers require 98% fill rates instead of 95% for some group of products. How much more safety stock do I need to hold and what is the inventory cost of providing this level of fill rate?

- How much can I reduce inventory if I can cut down the supply lead times by 20%?
- How much can I reduce inventory if demand variability improves by 10%?
- (For retailers) How much supply do I need for a group of seasonal products in order to maximize my seasonal profit from them?
- (For retailers) What is the best inventory policy if I want my customers to see at least 10 items on the shelf 95% of the time? What happens to my inventory if I want them to see at least 5 items 90% of the time instead?

Reports

To support conducting what-if analysis and daily inventory management activities, a number of Key Performance Indicators (KPIs) are calculated and reported. These KPIs help analysts understand the consequences of any changes they contemplate making in inventory policies, service levels and other parameters.

Reported KPIs include:

- Safety Stock (in units, dollars and days of supply) by SKU
- Lot Size (in units, dollars and days of supply) by SKU
- Reorder Point (in units, dollars and days of supply) by SKU
- Projected Average Inventory (in units, dollars and days of supply) by SKU
- 95% Confidence Interval for Inventory On-Hand (in units) by SKU
    - Max inventory on hand projection
    - Min inventory on hand projection
- Service Level Projections by SKU
    - Fill rate projection
    - On time delivery projection
    - Probability of no stock-out projection
- Aggregated Projected Average Inventory (in units, dollars and days of supply)
    - By Plant
    - By Material Group
    - By Product Hierarchy
    - By ABC class