

Using Performance Measurement to drive Continuous Improvement

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1.0 Introduction

The performance measurement revolution started in the late 1970s and early 1980s with the dissatisfaction of traditional backward looking accounting systems. Since then, there has been constant development in this field. If we look back and see “What is Performance Measurement?” According to Neely et al (1995), Performance Measurement is the process of quantifying effectiveness and efficiency of actions. What is the purpose of Performance Measurement? Its purpose is to monitor and improve the performance of these actions on a continuous basis. In other words, Performance Measurement is a continuous improvement tool.

In most organisations continuous improvement is a buzzword, but what is continuous improvement? How can it be achieved? Continuous improvement to the investors is to improve financial results, to the senior management it is to improve the business results, to the middle management it is to improve the processes, and to the operational staff it is to improve the activities and functions in which they are involved. In order to achieve all of these objectives (and hence achieve continuous improvement), the performance measurement system should assist in:

- * Identifying key areas that need improvement
- * Diagnosing and analysing the reasons behind low performance
- * Planning and implementing changes necessary to improve performance in a quantifiable or measurable way
- * Monitoring the results to find whether they achieved the expected results
- * Developing a closed-loop control system to promote continuous improvement

2.0 Performance Measurement Systems

Although there are several frameworks and models for performance measurement, Balanced Scorecard is a widely accepted model. It is a set of measures that gives top managers a comprehensive and balanced view of the business by including financial measures, customer satisfaction measures, internal process measures and innovation and improvement measures (Kaplan and Norton, 1992 & 1996). Although it was developed originally in the early 90s, since then it has evolved considerably.

The other well known performance measurement tools and techniques are: Strategic Measurement and Reporting Technique (SMART) (Cross K F and Lynch R L, 1989), Cambridge Performance Measurement Systems Design Process (Neely et al, 1996), Integrated Performance Measurement System Reference Model (Bititci et al, 1998) and Performance Prism (Neely et al, 2001).

3.0 Role of Performance Measurement in Continuous Improvement

Although many people make decisions intuitively (based on experience) in finding the key areas of improvement for their business, it is not always easy and accurate. There is a need for a systematic closed-loop approach that promotes improvement on a continuous basis. Deming proposed that business processes should be analysed and measured to identify the sources of variations that cause processes to deviate from customer requirements. Deming also recommended that the closed-loop control system should be used by managers to continuously monitor the performance of processes (business and manufacturing) to identify and change the parts of the process that need improvements. In Figure 1, Deming's PDCA cycle for continuous improvement is illustrated together with its performance measurement implications.

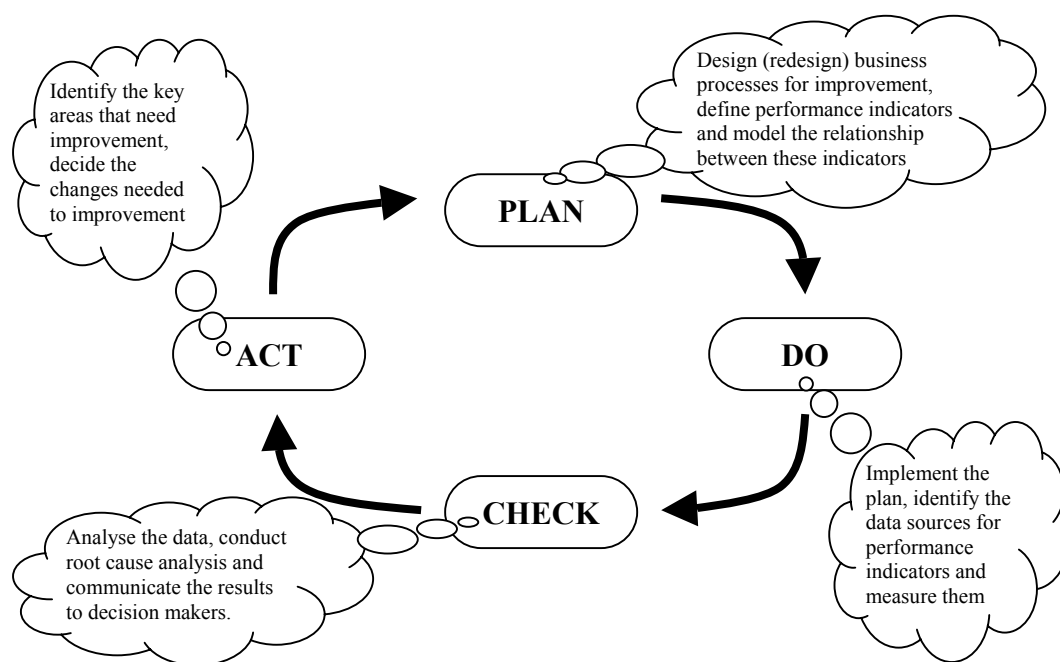


Figure 1. Deming's PDCA Cycle

One of the key activities that make a significant impact on continuous improvement is defining the performance indicators and modelling their relationship, which is the main focus of this paper.

Let us take a practical example of improving Order Fulfilment Process in a bottling plant. The various activities within the Order Fulfilment Process are represented in Figure 2.

Typically, there are two key indicators that are used for improving the order fulfilment process. They are "On-Time-In-Full" (OTIF) and "Process Cost". The problem with these indicators is that they are lagging indicators, i.e. by the time these indicators show poor performance, the situation is out of control. For instance, if the OTIF is 70 %, it implies that 30 % of the orders are already late. It is too late to do anything about it. So, what is required is a set of leading indicators that would effect

the performance of OTIF and Process Cost. Usually these leading indicators relate to the inputs of the process or the activities within the process or even outputs of the process. It is these leading indicators that need to be monitored to ensure that the process does not go out of control. The question is how do we find these leading indicators? And how do we monitor and manage them?

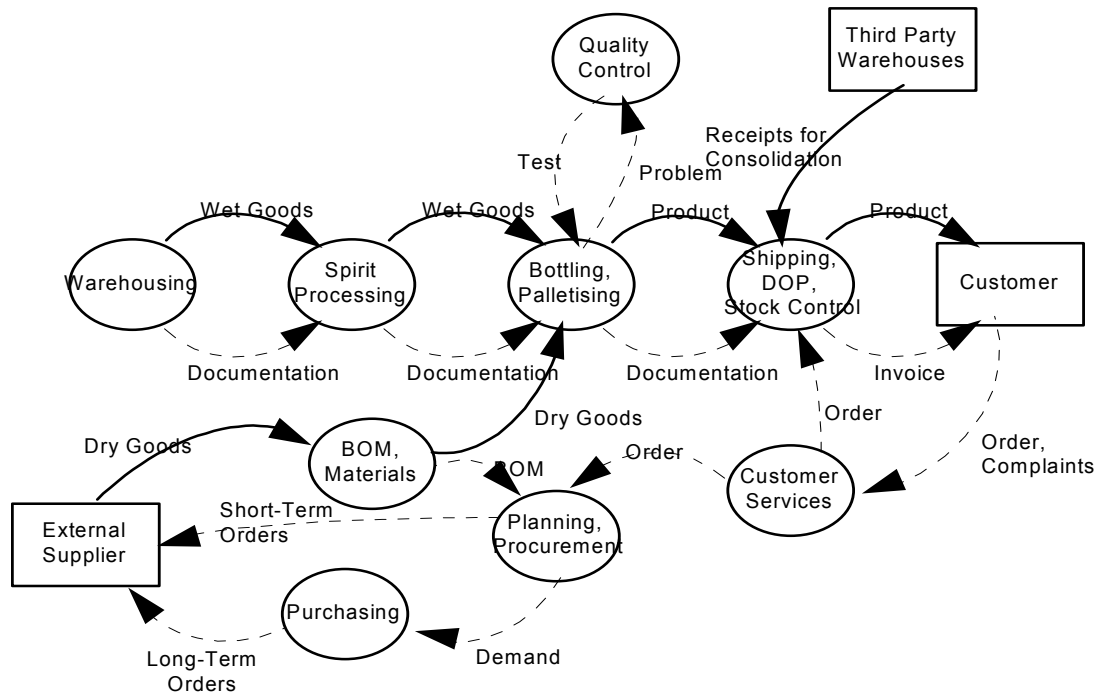


Figure 2. Order Fulfilment Process in Bottling Company

How to develop Leading Indicators?

Cause and Effect diagrams can be used to identify the leading indicators that affect the lagging key performance measures. This is not a new concept, it has been in practice for many years. Figure 3 illustrates the use of a Cause and Effect diagram to identify the causes and leading indicators that would effect OTIF.

In Figure 3, there are eight boxes, each corresponding to an activity in the process shown in Figure 2. For each activity, which may cause a problem with OTIF, the inward row is the leading indicator to monitor that cause, e.g. % OTIF can be affected by the activity “Bottling, Palletising”, but this activity can be controlled by monitoring “Bottling Plan Hit Rate”, a leading indicator. This leading indicator, in turn, can be affected by many causes, such as Quality, Breakdowns, Absence of Daily Priorities, Labour Supply and Skills, Material Supply and so on, which can also be used as leading indicators to manage the “Bottling Hit Rate” performance.

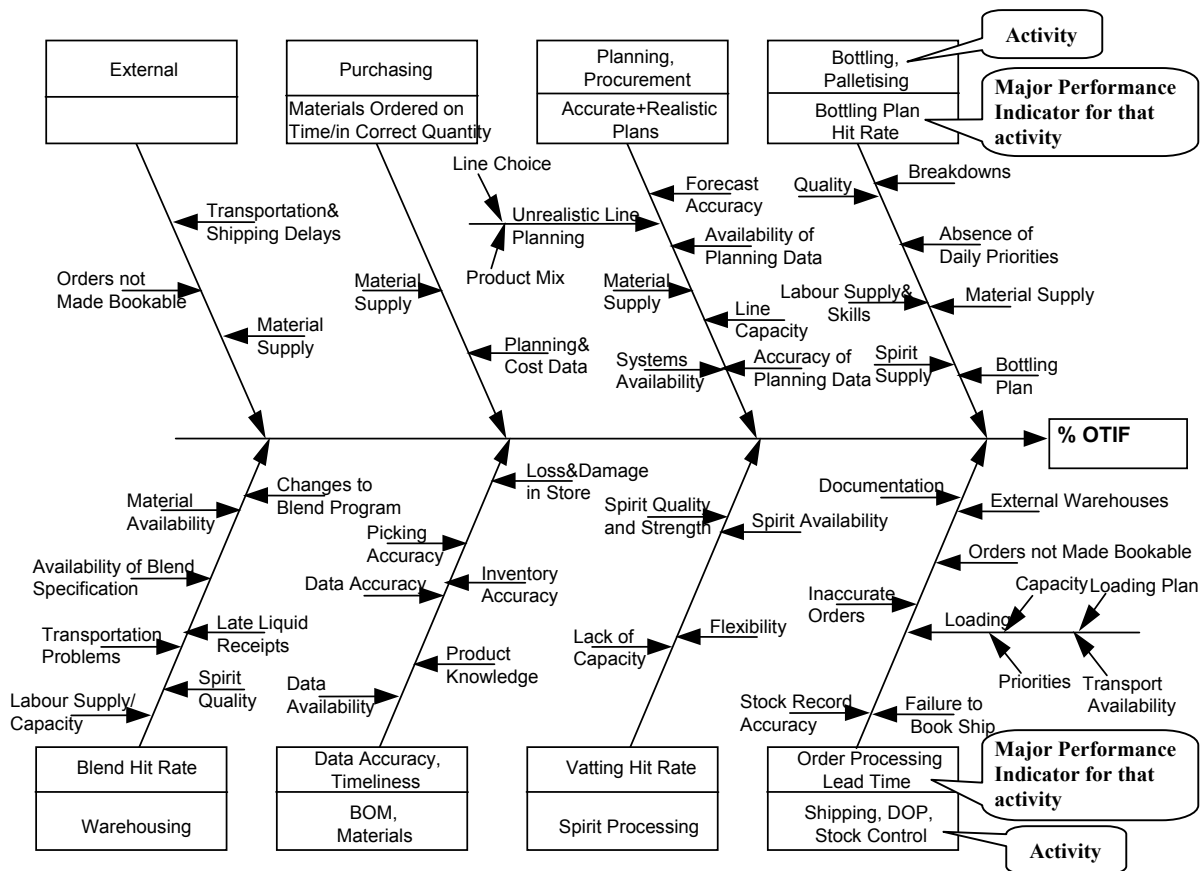


Figure 3. Cause and Effect Diagram showing causes effecting “% On Time In Full”

How do we monitor and manage them?

To facilitate continuous improvement these indicators need to be deployed right down to operational teams who use them to monitor, control and improve daily activities. These indicators should be:

- * Simple to understand and use
- * Relevant
- * Visual
- * Accurate and reliable

It is also important to make a clear distinction between improvement indicators and control indicators. Improvement indicator is one that needs to be measured for an improvement. Control indicator is one that does not require improvement but has to be monitored in order to ensure that the process does not go out of control.

To drive continuous improvement, the operational teams should move with the right set of leading and lagging indicators to monitor performance of their activities and focus their improvement effort. Management must ensure that the emphasis is placed

on future performance, i.e. using the leading indicators to drive improvements that would result in improvements in the lagging performance measures – e.g. improving downtime will improve the Bottling Plan Hit Rate, thus improving % OTIF. In this way people start thinking more proactively as they control the future.

But how can we facilitate the operational teams to manage the future?

Failure Mode and Effect Analysis (FMEA), a risk management tool commonly used in product design, process engineering and risk management providing a useful solution. FMEA allows the operational teams to prioritise the potential impact of each cause (failure mode) according to its:

- *Frequency of occurrence:* How often can a failure mode occur? The rating scale ranges from Very Often = 10 to Very Rare = 1.
- *Severity:* Once a failure occurs, how severe would its impact be on the problem one is trying to control? The rating scale ranges from Very High = 10 to Very Low = 1.
- *Detectability:* How difficult or easy is it to detect the occurrence (or possible occurrence) of a failure mode before it affects the process performance? The rating scale ranges from Very Difficult = 10 to Very Easy = 1.

Figure 4 illustrates an example of an FMEA chart that was created by the Bottling and Palletising team to monitor and improve “Bottling Plan Hit Rate” performance.

Failure Mode Hit Rate → OTIF	Occurrence	Severity	Detectability	RPN (Risk Priority Number)
Breakdowns	6	9	7	378
Absence of Daily Priorities	5	6	6	180
Quality	3	4	5	60
Material Supply	2	7	4	56
Bottling Plan	3	7	4	84
Spirit Supply	2	7	4	56
Labour Supply and Skills	1	3	3	9
Total				823

Figure 4: FMEA for Bottling Plan Hit Rate (before improvement)

In the above example, FMEA is used as a tool to analyse and prioritise the potential failures according to their risk. In this example – the order fulfilment process has an inherent unreliability of 823 with respect to Bottling-Plan-Hit-Rate (Hit-Rate) performance, where the total RPN can be used to drive improvements in this process. In our experience, a significant reduction in RPN usually results in a significant improvement in the output measure (i.e. Hit Rate in this case).

In this case, by taking two actions the RPN was reduced from 823 to 427. These actions were:

- Introduction of simple condition monitoring systems and procedures into critical parts of the bottling line. Thus reducing detectability to 3 as shown in Figure 5.

- Issuing daily priorities with each job so that high priority jobs are scheduled first. Thus reducing the impact of any breakdowns and stoppages on OTIF. This completely eliminated this cause and further reduced the overall RPN.

Failure Mode Hit Rate → OTIF	Occurrence	Severity	Detectability	RPN (Risk Priority Number)
Breakdowns	6	9	3	162
Absence of Daily Priorities	0	6	6	0
Quality	3	4	5	60
Material Supply	2	7	4	56
Bottling Plan	3	7	4	84
Spirit Supply	2	7	4	56
Labour Supply and Skills	1	3	3	9
Total				427

Figure 5: FMEA for Bottling Plan Hit Rate (after improvement)

In this case FMEA is used as a live operational tool, which is updated every time an improvement action is taken or every time one of the input conditions (i.e. failure mode, occurrence, severity, detectability etc.) changes.

Of course, to drive continuous improvement, it is essential that the operational team identifies and uses performance indicators to track performance against some of the failure modes, such as breakdowns, quality problems, material supply problems, etc., to allow them to identify and eliminate the root causes.

4.0 The difficulties with performance measurement

In the previous section we have discussed how to use performance measurement to manage continuous improvement. In fact, emphasis of the continuous improvement approaches, such as Lean Manufacturing and Six Sigma, is just what we have discussed so far. But when we do all of these, what we get is:

- Few measures at higher levels for senior management, easy to manage as they are measured on a monthly and annual basis and there are only a few of these.
- A lot of measures at lower levels for operational teams, difficult to manage as they are measured on an hourly and daily basis and potentially there are a lot of these.

Considerable effort is required at all levels to collect, analyse and report performance measurement information. According to Bititci et al (2000), Bourne and Neely (2000), Hudson et al (1999), Bierbusse and Siesfeld (1998) performance measurement fails in many companies for the following reasons:

- A lot of time and investment is required for data collection, analysis and reporting.
- Very difficult to quantify results in areas that are more qualitative in nature.
- The large number of measures, which are difficult to be managed on a paper-based performance measurement system.
- Lack of proper IT support.

The bottom line is that without appropriate IT support, Continuous Improvement with performance measures and indicators become very difficult and short-lived.

5.0 IT support for performance measurement

In the last decade, there has been an enormous growth in the number of software applications offered for performance measurement. Most of them are based on Balanced Scorecard. These performance measurement software applications are developed for data communication, integration, analysis and representation to different sets of audience. Most of this software offers comprehensive functionality, which makes it difficult in distinguishing between these applications. Each software is good at providing certain functionality for specific organisations. The software available to support performance measurement can be classified as:

- Business Intelligence (BI) is a continuous and systematic process, which produces information on a company's operating environment in a timely manner and usable form so that it can have positive impact on business processes. Effective Business Intelligence will facilitate the improvement of business processes and reduces the time used for decision-making. Typically, it includes software functions, such as data sourcing, data analysis, risk assessment and decision support, etc. It includes software tools, such as Data Marts, Data Warehousing, On-line Transactional Analysis tools, Multidimensional Databases or On-Line Analytical Processing (OLAP) tools, Ad-hoc and Prepackaged Query tools etc. Typical BI platforms are provided by: Oracle Corp., Hyperion, SAS Institute, Cognos Ltd., Pilot Software Ltd, SAP Ltd., PeopleSoft, CorVu Plc., Gentia Software Ltd., Comshare etc.
- Enterprise Resource Planning (ERP) Platforms: An ERP system is a multi-module software system that includes a central relational database and several software modules for managing purchasing, inventory, production, personnel, shipping, customer service, financial planning, and other important aspects of the business. A number of ERP vendors have started to integrate performance measurement as a module or feature within their ERP platform, e.g. SAP Ltd., PeopleSoft, Oracle Corp. Ltd. etc.
- Dedicated Performance Measurement Platforms: These are software platforms that allow organisations to implement performance measurement frameworks such as Balanced Scorecard, EFQM, etc. Typically it collects the performance relevant information from different sources, analyses the information and communicate the information to different stakeholders, who make decisions. Vendors of dedicated performance measurement platforms include PB Views Ltd., QPR Software Plc., Inphase Software Ltd., Hyperion, Cognos Ltd., Lucidus Ltd., PT. Global Performa Maxima, QuantiSoft, Gentia Software Ltd., IPS-Sendero, Comshare, Active Strategy etc.

Even though ERP platforms were classified separately, vendors who offer performance measurement within ERP modules are not yet common. Therefore, most of the IT based PMS applications are built upon Business Intelligence or Dedicated platforms, which have the capability of integrating with company's existing ERP and other systems.

In order to understand these software platforms in depth, a structured review has been conducted (Nudurupati and Bititci 2001) based on the user criteria gathered from Scottish based manufacturing companies. The results of the review are that most of the software and solutions themselves are:

- Expensive specially for manufacturing SMEs – Typically ranging from a minimum of £30k for software alone, plus consultancy, plus training, plus development time
- Most of the software applications have limited capability of incorporating statistical analysis to support Six Sigma type of improvement processes.
- Most of the software are based on Balanced Scorecard, and hence, the functionality is more restricted to this particular framework.

The review resulted in a detailed report on each software product against standard criteria identified. A sample report is included in Appendix A, and the full report is available from the Centre for Strategic Manufacturing, University of Strathclyde. The report also includes a spreadsheet (MS Excel file), which helps prioritising the criteria for an enterprise. This facilitates tailoring of the criteria giving ratings for different software products, based on individual organisational priorities.

6.0 Conclusions

In this paper we demonstrated that the quality of improvement depends on the quality of leading and lagging performance indicators. For this reason, several tools, such as Process Mapping, Cause and Effect analysis and FMEA, needs to be used in an integrated way with performance measurement models, such as Balanced Scorecard, Integrated Performance Measurement System, Performance Prism and so on. However, in our experience, this alone is not quite enough due to the amount of effort required to monitor performance indicators at operational levels. Providing IT support will eliminate some of the problems and promote sustainable continuous improvement.

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Appendix A

Background:

Founded in 1991, VENDOR is a company to design and implement Balanced Scorecard software. It implemented Balanced Scorecard software for a major bank in the UK. The first general release of Client Server version was released in 1998. The fully web enabled version 3.01 was released in Autumn 2000.

At the time of doing this review in Summer 2001, the web-enabled version of the product is less than one year old.

General Overview of Software:

Software supports the whole enterprise with a fully web enabled *out-of-the box application* (ready-to-use). It is offered as stand-alone software and is not a part of ERP or Business Intelligence solution, but it is compatible (or can be linked) with them. Since it is based on Microsoft Technology, it can also be tailored to one's requirements using Microsoft Office applications.

Adapting different frameworks

It contains number of pre-built frameworks for a number of performance management approaches, including Balanced Scorecard, Business Excellence Model etc. The users can ignore these pre-built frameworks and can build their own framework using templates. But the software was built based on Balanced Scorecard.

Deploying Performance Measures

It supports the deployment of strategic and tactical objectives and measures to any level in the organisation, providing graphical interfaces and point click wizards to enable users in defining the objectives and measures. Objectives and measures can be cascaded down to the team or individual level if required, and can be related to multiple perspectives or lines of reporting. These multiple perspectives include the classic Balanced Scorecard perspectives, but may also include process views, functional views, and any other reporting needs defined by the organisation.

Measures are defined by the organisation, and then held in a library for future use. New measures can be created at any time, and the details for existing measures edited, if necessary. Predefined measure libraries are not included in the software.

Objectives are generally prioritised through specific keywords to define different kinds of priority (e.g. High Payback, Regulatory Requirement, Low Cost). These keywords can be used to drive the graphical display of objectives, to give instant visualisation of levels of priority. Objectives and their measures are linked through different kinds of Cause and Effect relationships.

Data collection and maintenance

Software includes a simple spreadsheet like a database to be used as stand-alone software. It also supports a standard SQL RDBMS – by default, this is Microsoft SQL Server 7 or SQL 2000. Hence, data can be imported and exported directly from and to any ODBC compliant database.

Software Administrator includes an interface to enable the Model Administrators to map the contents of the flat files to Software objectives and measures. Once this mapping has been completed, the future importing of data can then be scheduled to run automatically.

Analyses of data

Graphical scorecards based on specific objectives, or on groups of objectives or measures, can be set up by the users. These enable the planned and actual performance of performance measures for the current period and the year to date to be displayed using “traffic-light” icons and values. The software applies default values for configuration parameters, which speeds up the creation and maintenance of entities.

Colour coded variances are shown against several ‘plan’ lines at once – these plan lines are user definable, and can include competitors, best in class benchmarking, 3 or 6 month forecast, etc. Trend tables can show periodic data, accumulated data, or normalised scores, simply by choosing the appropriate option from a selection list. Data is graphed and analysed dynamically in Excel providing access to the extensive statistical analysis available in Excel. It does not support any charts and statistical analyses that are not available in Excel. Users can add graphics, comments, and other elements to charts. Eventhough it differentiates the measures with priority it does not differentiate between control measures and improvement measures.

Reporting and communicating results

It displays the performance of objectives and measures in scorecards, and in networks, which can for example, be used to demonstrate cause and effect links through different perspectives. All reports are dynamically available on the web. It displays the values for each objective and measure in a wide range of table and graphical styles. Chart styles can be saved for re-use. All reporting views – Networks, Tables, Graphs, Cubes, Associated Documents, etc – can be combined into user-defined Briefing packs. These Briefing Packs may be passive or active, depending upon the needs of the user.

Associate or integrate with any Microsoft office document – Word, Excel, PowerPoint, Project – with any objective or measure, enabling the use of locally customisable templates and reports within Software reports and briefing packs. Data in both reports and briefing packs is automatically updated by Software from the underlying Software database.

It does not include any Web Server but it supports Microsoft Internet Information Server to communicate these results. It also supports Microsoft Discussion Server for threaded email discussions. Documents can be edited directly, enabling comments and suggestions to be shared immediately over the web. Documents can be emailed to forward comments, etc. Alerts can be configured to email the owner of the objective or measure if performance goes out of tolerance.

Minimum Hardware/Software Requirements:

Server Hardware: Pentium PIII, 750MHz, 512GB RAM, 2GB Disc space

Server Software: Microsoft NT Server 4.0 or later (or) Microsoft Windows 2000 Server & Microsoft Internet Information Server 4, Microsoft Transaction Server 2.0 Service pack 1 or later, Microsoft SQL Server 7.0 and OLAP Services Pack 3 or later.

Client Hardware: Pentium PII, 233MHz, 64MB RAM, 20MB free Disc space

