Calculating ROI for Automation Projects

Douglas C. White, Emerson Process Management

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By

Douglas C. White
Emerson Process Management

Introduction:

“Not again.” thought Bob. “The new system that we proposed is not on the approved projects list. This is the second year in a row it hasn’t make the cut. I thought everyone here supported the purchase. It would make the plant run better and sure make our life a lot easier. I just don’t understand how those in the head office make decisions. I bet they’ve never worked in an actual plant.”

Perhaps the comments above are familiar. Those of us in the automation field are very interested in new technologies and the opportunities they provide for improved performance. However, plant and corporate management must be concerned with business issues and overall plant profitability. Every company has limited funds available for investment with many more claimants than can possibly be funded. This difference in view often leads to misunderstanding and confusion.

New technology is of value only if it provides a suitable financial return. Many articles have been published on the potential economic benefits and return on investment (ROI) of installation of new automation and advanced automation technology in the process industries. Unfortunately the benefits claimed are often unrealistic and unsubstantiated. This leads to significant credibility issues when the forecast benefits are not achieved and to a lack of confidence on the part of management on proposals in this area. In this article a short review of the proper way to perform financial analysis for these technologies is presented. Hopefully this can help Bob, and you, obtain support for the next automation investment of interest.

Review of Plant Economics

The first step is to examine the plant as a financial asset. We may think of plants as a collection of equipment and personnel that convert raw materials into products. From a financial point of view, a plant is an asset that consumes money and produces money, hopefully producing more than is consumed. The major monetary components are shown in the figure following:

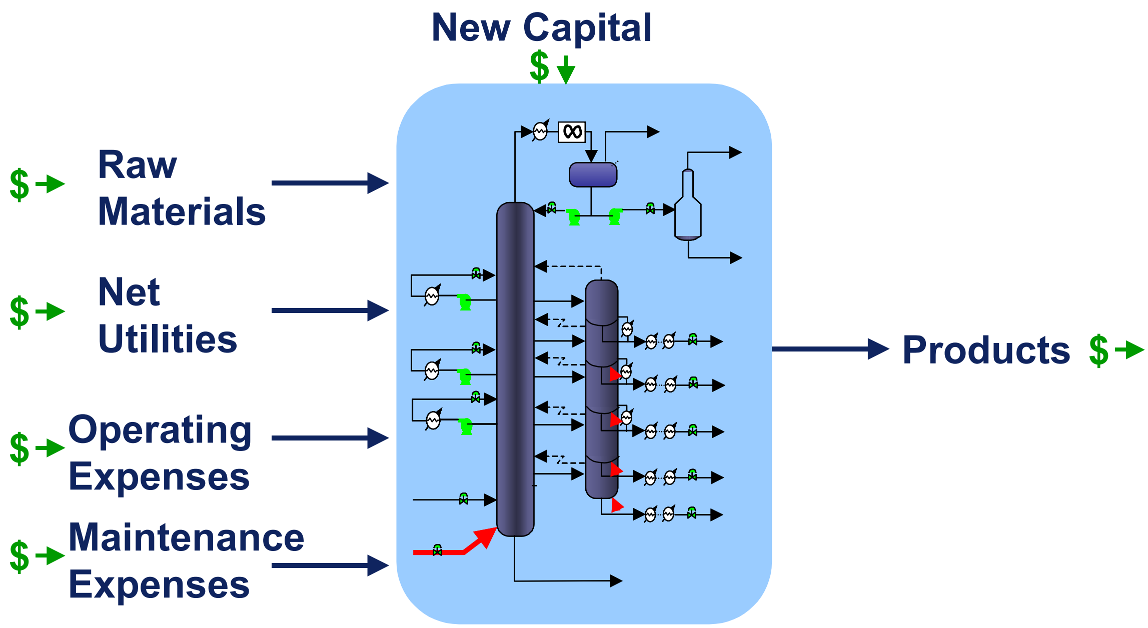

Figure 1: The Plant as a Financial Asset

By convention, financial inputs are classified as either capital or expense. Expenses include all the ongoing costs of producing the products such as raw materials, net utilities (used less produced), operating costs, maintenance expenses, and other miscellaneous costs. Capital has two components – working and investment. Investment capital refers to the cost of major equipment or system additions that will last for several years and can be depreciated for tax purposes. Working capital is the value of inventory and required net short term financial funding.

Return on Invested Capital

To properly prepare an investment evaluation we must understand the language and objectives of the plant's financial management. In this section a quick overview of the subject is given. For more background and a more comprehensive review, see standard financial analysis references such as Brealy & Myers (2003).

Ultimately the management of a company has an obligation to increase the long term financial value of the corporation to its owners, who are normally the shareholders. This value can be measured in many ways but stock market valuation is one of the more important and ultimately is a function of financial performance. There are equally many ways of evaluating financial performance but the primary measure used here will be Return on Invested Capital (ROIC). This is not only a good internal measure but also correlates with long term stock market performance. The consulting company, McKinsey (Auget et al; 2003) recently published results of a study by of 130 publicly traded chemical companies in the US and Europe and their financial and market performance over 40 years. Their conclusion: "only returns on invested capital drive market-to-book valuations."

ROIC is illustrated in the figure following.

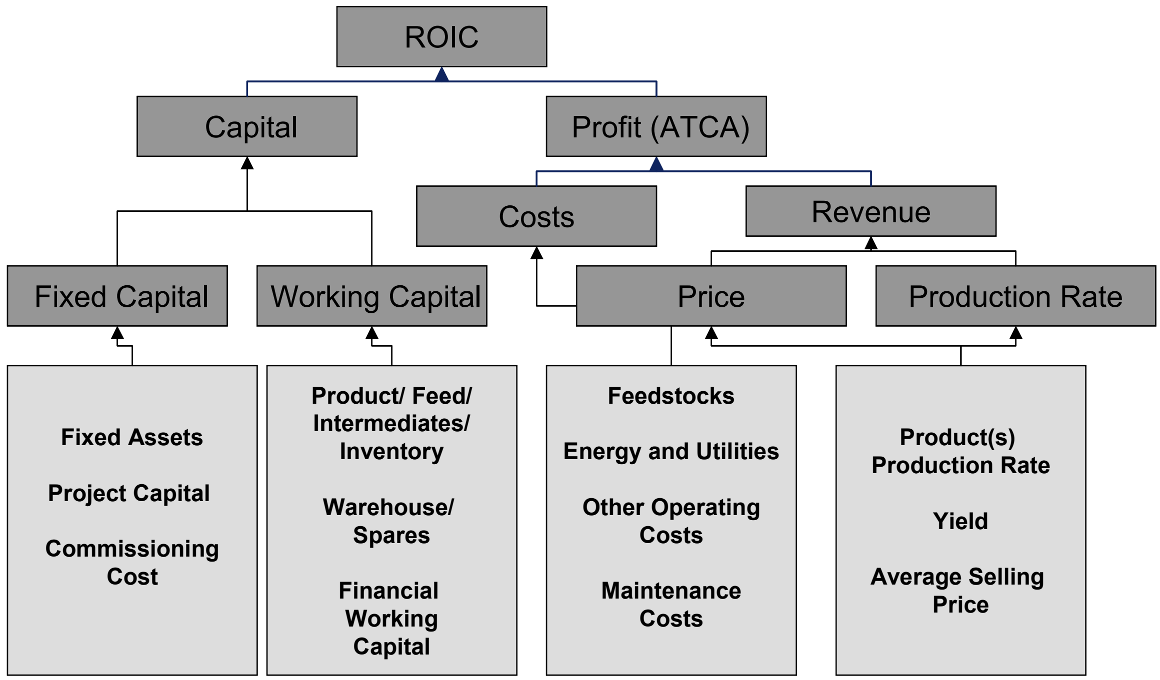

Figure 2: Return on Invested Capital

The yearly ROIC equals the profit measured as after tax net income (cash adjusted) for the year (ATCA) divided by the invested capital at the start of the year. Invested capital equals net fixed capital plus working capital plus other assets. In the boxes at the bottom are listed the primary manufacturing variables that affect the ROIC. Variables listed are restricted to those where decisions made by plant personnel affect the financial results. Land taxes, for example, are a plant expense item but tax rates are not normally within the control of plant staff. In the fixed capital area, the variables include fixed assets in the plant such as the equipment plus new project capital and project commissioning costs, which are normally capitalized. Working capital equals operating cash plus inventory (including spares) plus financial working capital (accounts receivable minus accounts payable). The primary ongoing expenses were shown in the first figure and include feedstocks, energy, other operating costs, and maintenance costs. Revenue is the product of production rate and average selling price. Typically ROIC will be evaluated as an average over several years to smooth normal yearly fluctuations and give a better long term measure.

Automation and ROIC

From a financial point of view, the plant objective is maximize the long term ROIC. How can automation and advanced automation can affect manufacturing cost and revenue components? The key effects are summarized in the figure below:

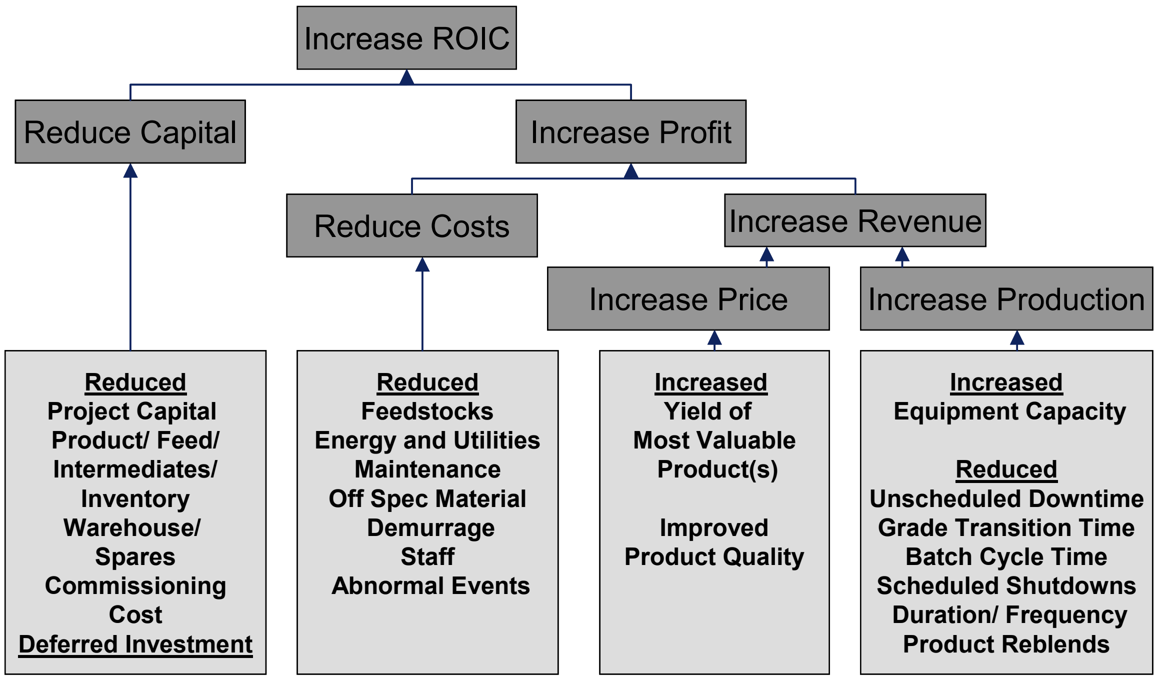

Figure 3: Potential Automation Effects on ROIC

To increase ROIC, capital must be reduced or profit increased or preferably both at the same time. The primary areas where automation and advanced automation savings are normally found are illustrated in the boxes at the bottom of the figure. When a project is considered, all possible savings areas should be evaluated.

Potential capital savings include both fixed and working capital components. Potential project capital cost reductions due to automation choices can include savings in:

- Engineering
- Procurement Costs
- Purchase Price
- Installation, Configuration, Calibration & Commissioning
- Project Execution

Working capital can be reduced by reducing raw material, intermediates, and product inventories and also by reducing owned spares for equipment stocked in the warehouse. Capital deferred also results in savings due to the time value of money. Deferred capital can result from longer equipment life due to better control or from more production from the same equipment which results in a postponed plant expansion.

Expenses can be reduced by lowering energy /utilities usage and decreasing raw material costs through increasing yields of desirable products. In special cases it may be possible to substitute a lower valued raw material.

There are several types of maintenance costs including:
- Scheduled Maintenance
- Unscheduled Call Out
- Major Shutdown

Reductions can occur in all types of maintenance costs due to improved automation performance and enhanced monitoring of process equipment. Specific savings can include reductions in:
- Unscheduled maintenance
- Number of routine checks
- Time to perform required maintenance tasks
- Maintenance materials purchase
- Number and costs of required tasks during scheduled shutdowns

Reduced off specification material can lower reprocessing costs. Demurrage is the cost charged by ships waiting to load. Waits beyond contracted amounts incur penalties. In selected cases it may also be possible to reduce average staffing levels.

Abnormal event prevention deserves some special comments. Reducing Health, Safety, and Environmental (HS&E) issues is at the top of every plant manger's agenda. Improved automation is often a key to reducing these types of events. If your proposed investment will result in safer operation or reduced emissions it should definitely be included in the justification description even if no quantitative economic value can be attached to these improvements.

Next is the area of increased average selling price for products. Automation can contribute to this goal by increasing the yield of more valuable products. Reduced amounts of lower valued byproducts will increase average revenue per unit feed. Off specification material, which can be reduced through improved control, usually brings a discounted selling price. Occasionally an increase in product quality due to improved control will actually permit selling the existing product(s) at a higher price.

With regard to increased production, the key question is whether or not the additional product(s) can be sold. Increases are only financially valuable for production limited plants, i.e. those manufacturing products where the market can absorb the increases. If not, no benefits can be claimed for the improvements. Increased production can result from the capability, with better control, to operate closer to production limits at constant product quality. Increased production can also come from reduced unscheduled downtime for equipment due to better reliability, shorter batch cycle times, lower grade transition time, less product reblending, and decreases in scheduled shutdown duration and frequency. The shutdown frequency can be reduced, for example, by increasing a furnace run time between required decoking or not cleaning a heat exchanger prematurely.

To estimate the potential magnitude of the savings, examine the normal expenditures and look for specific quantifiable areas where savings are possible. Often historical data will provide a basis for this analysis. External consultants with experience in this area can also help insure that potential savings are not overlooked and that there is proper documentation for the estimated savings used for the justification.

Investment Costs

Next investment costs must be estimated. When performing investment analysis, it is important to consider the full life cycle costs, not simply the initial purchase price, of new equipment and new software systems. Many studies have shown that more than two-thirds of their life cycle costs occur after installation.

In the project initial, or capital costs area, include the following:

- Hardware purchases
- Installation costs
- Required infrastructure upgrades – networks, etc.
- Software licenses
- Application specific services – design, configuration, custom coding, database population, system installation, integration and commissioning
- Training – System support and end user
- Project expenses – project management, purchasing

Ongoing maintenance and support cost estimates should similarly include:

- Hardware support agreements
- Hardware upgrades
- Software support agreements
- Internal support costs
- Ongoing required infrastructure upgrades
- New release migration costs
- Ongoing system support training
- Ongoing user training

Don't forget the last item. Make sure that you budget for ongoing training. The best long term job security today is maintaining your and your staff's skill levels and expertise current. It is easy to fall into the trap of being so busy with day to day problems that you lose sight of the longer term requirements.

Investment Analysis

We now have benefits and costs. How are these converted into a proper overall project financial analysis? How can we demonstrate that the proposed investment will increase the long term corporate ROIC more than other potential investments?

Although the specific investment evaluation protocols vary from company to company and you need to follow your company's guidelines, they all have at their center the calculation of the net present value of the incremental after tax benefits generated by the plant due to the equipment or technology and comparing it with the net present value of the required investment. In financial terms, all assets, be they stocks, bonds or chemical plants, are valued the same, i.e. as the net present value of the future sequence of after tax cash flows. If the value is greater than the investment the project is considered for funding. Net present value implies discounting a sequence of net cash flows (receipts less expenditures) back to the current time. But there are many subtleties.

Initially it might be thought that the proper discount rate is one simply a little higher than the average corporate ROIC calculated above. If the investment value was positive then the ROIC would be increased and the investment justified. However, the correct selection of the discount rate is more complicated. Three interrelated factors must be considered. The first is that the cost of capital that the corporation has to pay for additional funds used for investments is significant and is different for each corporation. The cost is affected by the relative usage of debt and equity for the corporation and called therefore the *weighted average cost of capital*. Investments made by the corporation must obviously produce a return that exceeds this cost so the discount factor needs to be at least this amount. The second is that the corporation has alternative options for investment both within and outside the company. Since standard financial investments are available, the discount rate must be greater than the return from these investments or else the company will invest its money there. Alternatively the firm could pay a dividend to shareholders with the cash and the shareholders themselves could invest in these standard investments. The third factor, closely related to the second, is that not all investments are equal in the predictability of the cash flows produced. The cash flow from a new pump is likely to be much more predictable than that from a new software system that has never been installed in the plant before. In accordance with financial analysis theory and practice, when the actual value of the cash flow is not fixed, but can only be estimated, a risk premium should be added to the discount factor that recognizes the uncertainty or *riskiness* of the estimated cash flow. More complete explanations of these factors are available in standard financial analysis texts such as the one referenced previously, Brealey and Myers (2003). Again the standards used by your company should be the ultimate guide.

The financial analysts will then compare the profitability of various investment proposals from all parts of the corporation and rank them. One key ranking used is the profitability index defined below.

Let:
NPV(ATCF) = Net Present Value of After Tax Cash Flow generated by the investment
NPV(IC) = Net Present Value of Required Investment

$$\textbf{\textit{Profitability Index}} = 100 * \frac{\textbf{\textit{NPV(ATCF)}} - \textbf{\textit{NPV(IC)}}}{\textbf{\textit{NPV(IC)}}}$$

An outline of the equations underlying this expression is given in the Appendix. It is common to graph the sequence of investments and resulting cash flows as shown in the figure below. The elapsed time to positive cash flow, i.e. the time at which the discounted cumulative cash flow crosses into the positive region is also important. This is sometimes called the discounted payback period.

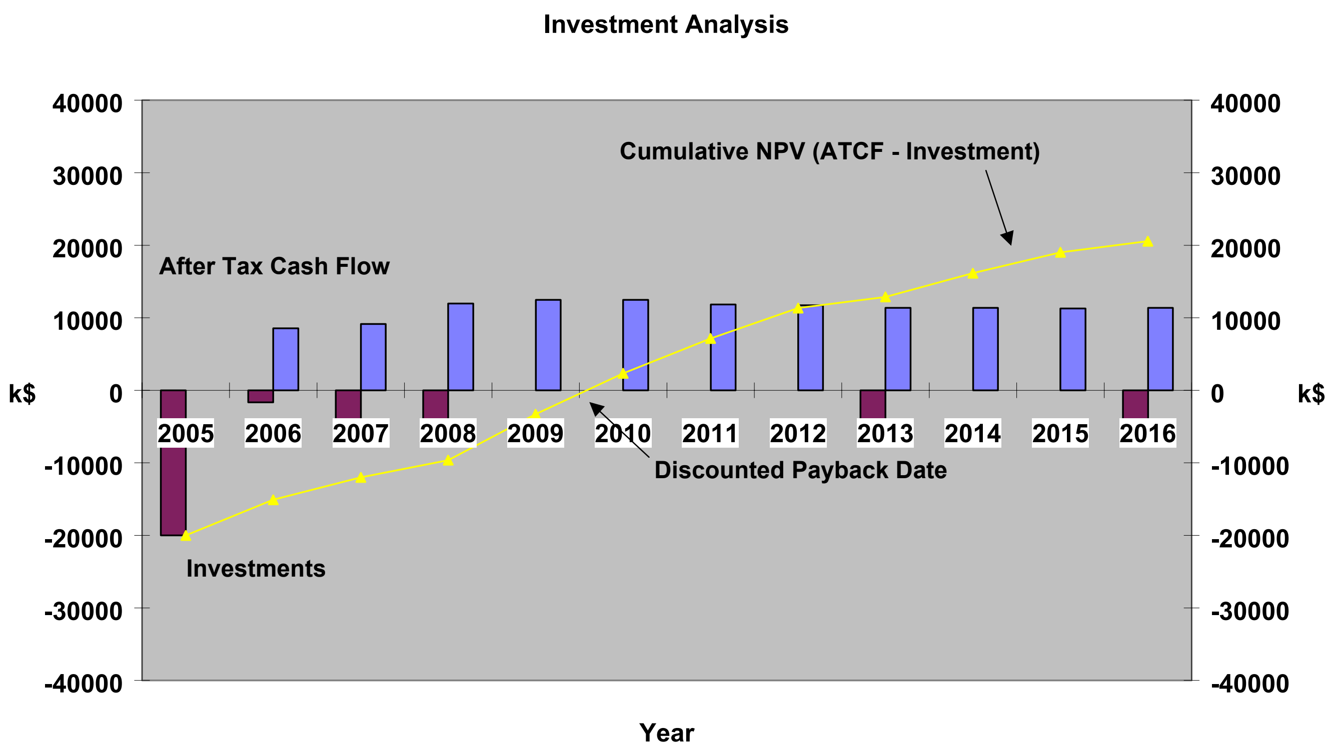

Figure 4: Cash Flow Profile

For your investment to be favored it should have a higher risk adjusted profitability index than others and a shorter discounted payback period.

Post Audits
A key discipline for long term successful project financial management is to regularly, rigorously and objectively post audit all major investments to see if they did or did not achieve their predicted return on investment. The first step in this process is to capture a set of base operating data prior to the installation of the system. This is compared with operating results after installation of the new system or technology and the improvement calculated. Correction to standard operating conditions or adjustments due to changes in raw materials or operating conditions are often required. Understanding problems areas and areas of unanticipated benefits leads to better evaluation of future investments.

Conclusion
We all want our preferred investments to be funded. However, to successfully obtain the money for these investments requires that we understand the criteria by which the financial management of the company allocates available funds. In this review the key points to consider have been summarized. By following these guidelines, Bob will hopefully be more successful next year and receive funding for the new system.

References
Brealey, R. A. and S.C. Myers (2003); Principles of Corporate Finance, 7th Ed.; McGraw-Hill Irwin
Auget,T.;E. Bartels & F. Budde; (2003) “Multiple Choices for Chemical Industry;” McKinsey Quarterly; 2003; Number 3; pp.126ff

Appendix (Return on Investment Calculation):
Let IC_i be the investment capital required in year i which is the sum of the project capital expenditure plus the increase/ decrease in working capital required by the investment. Working capital includes inventory and financial capital as the net of accounts receivable over accounts payable.

Let r_c be the corporate weighted average after tax cost of capital.

Consider the investment analysis for the period 2005 to 2015. The period chosen should be far enough in the future that all relevant investment effects and costs are considered. Then the Net Present Value in 2004 of the Investment is:

$$NPV(IC) = \sum_{i=2004}^{i=2015} \frac{IC_i}{(1+rc)^{(i-2004)}}$$

Let $ATCF_i$ be the incremental after tax cash flow in year i
Let CoV_{2016} be the continuing value of the investment in year 2016.
Let r_r be the risk premium to be applied to the expected returns from a particular investment. The Net Present Value of the cash flows is:

$$NPV(ATCF) = \sum_{i=2004}^{i=2015} \frac{ATCF_i}{(1+r_c+r_r)^{(i-2004)}} + \frac{CoV_{2016}}{(1+r_c+r_r)^{(12)}}$$

Let OM_i be the incremental change in operating margin in year i due to an investment where operating margin equals product value (P) less feedstock costs (F) less energy cost (E) less other operating expenses (O) less incremental maintenance and support costs (MS) for the investment, i.e.

$$\mathbf{OM_i = P_i - F_i - E_i - O_i - MS_i}$$

Let r_s be the incremental charge for SG&A (Sales, General & Administrative)
Let OE_i be the change in operating earnings due to the investment

$$OE_i = OM_i\ (\ 1 - r_s P_i)$$

Let r_t be the incremental tax rate for earnings
Let r_d be the depreciation rate for the investment
Then the after tax cash flow for the investment is:

$$ATCF_i = (OE_i - r_d\ IC)(1 - r_t) + r_d\ IC$$

Typical Values
To calculate returns several factors are needed:

r_c – weighted average cost of capital – usually in the 10% to 16% range for major corporations
r_r – risk premium – discussed in the next section
r_s – incremental charge for SG&A – 7% of sales revenue typical for process industries
r_t – incremental tax rate – typical rate 30% of earnings for process industries
r_d – depreciation rate – assumed five year life for computer hardware and software investments gives 20% straight line depreciation

Risk Factors
In the preceding analysis, a risk factor was identified for the expected returns from different investments. In general this factor reflects the variance or the uncertainty in the projection of earnings. If two investments have the same mean value for the expected earnings but one investment has a higher uncertainty than the other, the first will be assigned a higher risk factor and hence a lower net present value. In financial theory this risk factor can be calculated based on the variance of the change in value of a particular against the change in a benchmark asset. The specific areas of risk to be evaluated include:

Market Risk - Since feedstock costs and product(s) demand(s) and value(s) are not known in the future, there is a market risk which creates uncertainty in the estimated earnings. In addition the weighted average cost of capital is not actually known for the future as well. This risk will be uniform across all of the investment alternatives considered and should be built into the base discount rate used.

Project Execution Risk – With execution of any project there is always schedule risk, which relates to the project completion in the period assumed and cost risk. Cost risk refers to unexpected changes in the cost for delivery.

Performance Risk – After installation, there is a risk that the system may not achieve its expected performance and the earnings will be lower than expected when the system was justified. There is also a risk that the performance may degrade with time. This degradation may be due to reliability issues or to difficulties in maintaining a complex system.

Supplier Risk – There is a risk associated with choice of any supplier. Specifically will the supplier be able to deliver the software and services contracted. The supplier may be unable or unwilling to meet the contract due to financial problems, a change in corporate ownership, or loss of key staff.

Objectively evaluating these risks enables us to identify the overall expected variability in the projected earnings and to choose a risk factor that corresponds to this variability. Typical risk premiums will range from –2% for replacement equipment such as a pump to +15% for a new software system by a new supplier that has not been installed in the corporation or a similar corporation previously.

For more information:

Please visit our website www.EmersonProcess.com/solutions/AdvancedAutomation, or

Contact us at:

email: AAT@emersonprocess.com
phone: +1 512-832-3575

Emerson Process Management
12301 Research Blvd.
Research Park Plaza, Building III
Austin, Texas 78759 USA