The Use of Decision Criteria in Selecting Information Systems/Technology Investments

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Abstract

In a competitive environment, selecting and effectively pursuing the right information systems/technology (IST) investments can be a key factor in sustaining corporate viability and prosperity. This study examines the criteria used by 80 organizations in allocating strategic IST resources. Senior executives were asked to indicate which of 15 criteria they use in deciding among competing projects. They also identified how frequently the criteria are used and ranked them by importance. The results indicate that criteria such as the support of explicit business objectives and response to competitive systems are now important in selecting IST investments. Although financial criteria are used by most organizations, the extent of analysis and application appears to leave room for improvement.

Keywords: Project selection, information technology investments, systems spending, project evaluation and approval

ACM Category: K.6

Introduction

How are investment decisions made for new systems development, packaged software, machine upgrades, improved networks, emerging technologies, and other information systems & technology (IST) projects? Are such decisions effective in supporting strategic business goals, targeting the use of information systems & technology, and maximizing overall returns?

Making effective investment decisions for IST projects has become critical to the organization. The amount of money being spent on IST is now about half of all durable equipment spending, according to U.S. Government figures (Loveman, 1991). Overall, IST spending is running at about 2.7 percent of U.S. corporate revenues (Maglitta and Sullivan-Trainor, 1991). However, even these figures may not include what is suspected to be a large amount of decentralized IST spending (Davis, 1989). These figures also do not include the total organizational costs associated with IST investments (Keen, 1991).

At the same time, increasing economic and competitive pressures are compelling companies to scrutinize their IST operating and capital budgets very carefully (Wilder and Hildebrand, 1992). With decreasing margins and limited capital resources, companies must ensure these resources are allocated judiciously among competing projects. Thus, careful and correct IST investment (or project selection) decisions are becoming more of an economic and competitive necessity.

There is no uniform definition of what constitutes an IST investment, and not all investment in information systems and/or technology is of a capital nature. The current cost of processing and operations is clearly not. Neither is "routine" systems maintenance. But outlays for computer hardware, network facilities, and externally developed software products are clearly capital expenditures. In addition, in-house development projects involving new systems and significant enhancements would also seem to represent capital expenditures.

An IST capital investment is therefore defined as:

Any acquisition of computer hardware, network facilities, or pre-developed software, or any "in-house" systems development project, that is expected to add to or enhance an organization's information
Justifying IT Investments

systems capabilities and produce benefits beyond the short term.

This definition may vary from a general definition of capital expenditure that refers to "long-lived assets" (International Federation of Accountants, 1989). Considering the rapid rate of development and change in information systems & technology, there may be few IST investments that could be classified as "long-lived." Therefore, the definition of a capital investment for IST purposes includes any investment that looks beyond the short term, that is, anything beyond one year.

Capital budgeting is the process of planning for and deciding upon capital investments. It focuses on the evaluation of cash flows, based on the time-value of money, using discounted cash flow (DCF) techniques. DCF techniques reduce all estimated cash outflows and inflows associated with a given investment or project back to the present, so as to express everything in present dollar terms. Cash flows in different periods and in different projects therefore have a common basis of comparison. There are also non-DCF techniques that ignore the time value of money. These are the Payback Method (PBK) and the Accounting Rate of Return Method (ARR). PBK evaluates a project on the basis of how quickly it takes to pay for itself, whereas ARR divides the average annual income from a project by its initial capital investment. These non-DCF techniques are frequently used as "yardsticks" in conjunction with DCF techniques.

There are two basic DCF techniques:

Net Present Value (NPV), which discounts all estimated cash flows for a project to present value, using a required rate of return or "hurdle-rate." It may also be referred to as Expected Present Value (EPV), to reflect the incorporation of probability and expected value estimates (Thompson and Thuesen, 1987). If the present value of the cash inflows exceeds the present value of the cash outflows, including the initial capital investment, this will give a positive net present value and, thus, encourage project acceptance.

Internal Rate of Return (IRR), which aims to find the discount rate that would equate the present value of estimated cash outflows with the present value of inflows. If this rate is greater than the required rate of return, the project may be accepted.

A third technique, the Profitability Index Method, is an extension of the two basic discounted cash flow techniques. It provides comparative profitability among different investments by dividing the present value of future cash flows by a project's initial investment.

A limitation with current capital budgeting theory, insofar as it relates to investments in information systems & technology, is that its starting point is the cash flows as given; it essentially assumes that those cash flows are known. Even risk analysis only provides for the estimation of cash flows after the underlying flows have been determined. Therefore, capital budgeting provides little insight into the quantification of benefits and estimation of cash flows (Weaver, et al., 1989).

A further limitation is that capital budgeting theory in textbooks on the subject concentrates almost exclusively on the financial criteria (Brealey and Myers, 1988; Brigham and Gапenski, 1991; Van Horne, 1986; Weston and Brigham, 1987). While it might be said that every business decision eventually comes down to financial criteria, there are other criteria that should be, and in practice are, considered by the managerial decision maker. This applies particularly to investments in IST.

A third limitation is that current capital budgeting theory does little to address the organizational and behavioral factors involved in the practice of capital budgeting (Hellings, 1985; Kennedy, 1986).

Significance of IST Investment Criteria

There seems to be a greater need to define and enhance the way in which capital expenditure decisions are carried out in practice. In particular, there is an increasing need to subject investments in IST to more rigorous analysis and justification, comparable to that undertaken for other investments (Silk, 1990). This is especially important because some studies suggest that investments in IST do not necessarily provide a high return but may, in fact, result in costs that contribute to a loss in competitive capability (Loveman, 1991; Strassman, 1985).
Improvement in IST capital investment decisions should lead to more effective and efficient use of IST resources. The expectation is that there will be an improved targeting and more strategic use of IST resources with resulting positive impact, either directly or indirectly, on the overall profitability of the organization.

The basic question that might therefore be asked is:

How do organizations decide on their information systems and technology (IST) investments, and how _should_ they decide?

This question might be dealt with in the following terms:

(a) the _process_ in arriving at the IST capital expenditure decision, and (b) the _criteria_ or methods used.

The _process_ is concerned with the formal and informal organizational dynamics involved, starting with the initiation of an IST project or investment and culminating in review and approval. It answers the question: _how_ was the investment decision made? In some organizations it is a highly political process where the informal dynamics predominate (Weill and Olson, 1989). In others, the process may be more structured (Doll and Torkzadeh, 1987; McKeen and Guimaraes, 1985).

The _criteria_ are concerned with the financial and non-financial justification used in proposing, evaluating, and deciding upon the project or investment. They answer the question: _why_ was the investment decision made?

There has been discussion on whether financial criteria alone should be applied to IST investments, given the intangible and strategic nature of some of the benefits (Badiru, 1990; Davenport, 1989). There has also been some work on cash flow estimation and cost/benefit analysis methods (Due, 1989; Pohlman, et al., 1988). And since the early days of information systems, work has been done on the value of information (Boyd and Krasnow, 1963). There has also been comparable work in the related field of R&D project selection (Hall and Nauda, 1990; Kim and Kang, 1989). A significant work is Parker and Benson's (1988) book _Information Economics_, which considers IST investment benefits based on six classes of value: return on investment, strategic match, competitive advantage, management information support, competitive response, and strategic IS architecture. Also, Keen's (1991) book _Shaping the Future: Business Design Through Information Technology_ contains important material on managing the economics of information capital.

However, little empirical work has been done on the financial and other criteria actually used in practice in deciding on project selection and capital investments in IST. Yet this information would seem to be important as a platform for seeking enhancements in the way organizations decide on their investments in information systems & technology.

The criteria used in making the decision on IST investments have significance for a number of reasons. First, the criteria used or not used, and the way in which they are applied or not applied, significantly impact the effectiveness with which IST investment decisions are made. They determine whether the "right" projects are selected.

Second, the criteria are significant for the organization's finance and management accounting function in terms of their role in maximizing return on investment and their involvement in the cost vs. benefit analysis that may precede an IST capital investment decision.

A final reason why the criteria used in IST investments have significance concerns the right "balance" in the use of criteria. There are essentially two opposing views in considering cost vs. benefit analysis for the purpose of evaluating and selecting IST projects/investments. One view is that cost vs. benefit analysis, beyond an intuitive assessment, is neither feasible nor useful, especially when the numbers seem to be stretched to fit the need. This is reinforced by the belief that, even if the projected benefits are realized, it is difficult to prove that they are attributable to the IST investment. Neither is it always easy to quantify the "soft" or indirect organizational costs involved, which may be greater than the hard/direct costs (Hochstrasser, 1990; Keen, 1991). It has also been suggested that ROI analysis is applicable to transaction-oriented systems or to those undertaken for strategic, market-oriented purposes (Weill and Olson, 1989). All of this has some truth, and the quantification implicit in cost vs. benefit analysis may not always be feasible. In fact it may even turn into a "numbers game" that displaces real analysis. Nonetheless, quantification should always be attempted, and pro-
procedures should be put in place to ensure evaluation, screening, and benefit-tracking (International Federation of Accountants, 1989). Otherwise, there may be an absence of disciplined analysis, no real basis of objective measurement, and limited awareness of the true costs and benefits of IST investments (Hochstrasser, 1990; McKinnon and Kallman, 1987; Silk, 1990).

The other view imposes a universal requirement for a clear, measurable, and reliable return on investment over two to three years or less. It is oriented to traditional, cost-saving, productivity-oriented projects, and it tends to screen out those providing better customer service, improved decision support, enhanced communication, and similar strategic payoffs. It denies the reality of intangible benefits, ignores any beneficial “ripple” effects, and dismisses any associated cash inflows due to the difficulty of measuring such inflows (Downing, 1989; Parker and Benson, 1988). The problem with this view is that the traditional project often fails to produce the expected cost savings and productivity improvements (Economist, 1990; Strassman, 1985).

In summary, the criteria actually used tend to indicate whether there is an appropriate balance in utilizing both quantitative and qualitative forms of evaluation in selecting information systems & technology investments.

Methodology, Criteria, and Survey Sample

In an effort to gain some answers on the IST capital investment (project selection) decision criteria used in practice, a survey was undertaken in 1990 of 80 American, British, Australian, and New Zealand companies. A one-page survey form was developed with the aim of making it as easy as possible to provide the data requested. The form provided 15 possible IST investment criteria, a means of indicating whether they are used or not, the percentage of projects to which each criterion is applied, and an overall ranking in terms of total project value for each criterion. The criteria are defined in Appendix A and listed in Table 1.

The criteria are categorized into financial, management, and development criteria. They were developed, first, through interviews with 20 chief information officers (CIOs) in Britain and the United States. These CIOs were questioned on what criteria their organizations use in selecting IST investment projects, with the aim of developing a full list of the criteria used in practice. Second, the criteria and the form were tested and refined in a pilot study with 12 companies. The finalized survey form is shown in Appendix B, which demonstrates how a typical form would have been filled in.

The criteria used in the survey and listed in Table 1 are primary-level criteria. That is, they are oriented to the basic IST project selection and investment decision—the basic reason for the investment. This distinguishes them from secondary-level criteria, such as functionality or viability of hardware or software, that might be used in selecting a particular IST vendor. For example, the criterion Technical/System Requirements is not a secondary-level, vendor-oriented criterion. As indicated in Appendix A, it applies when hardware or software requirements are a major factor or need behind the investment decision.

Table 1. Criteria Used in the Survey of IST Project Selection (Investment) Decisions

<table>
<thead>
<tr>
<th>Financial Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discounted Cash Flow (DCF)</td>
</tr>
<tr>
<td>1. Net Present Value</td>
</tr>
<tr>
<td>2. Internal Rate of Return</td>
</tr>
<tr>
<td>3. Profitability Index Method</td>
</tr>
<tr>
<td>Other Financial</td>
</tr>
<tr>
<td>4. Average/Accounting Rate of Return</td>
</tr>
<tr>
<td>5. Payback Method</td>
</tr>
<tr>
<td>6. Budgetary Constraint</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Management Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Support Explicit Business Objectives</td>
</tr>
<tr>
<td>8. Support Implicit Business Objectives</td>
</tr>
<tr>
<td>9. Response to Competitive Systems</td>
</tr>
<tr>
<td>10. Support Management Decision Making</td>
</tr>
<tr>
<td>11. Probability of Achieving Benefits</td>
</tr>
<tr>
<td>12. Legal/Government Requirements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Development Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Technical/System Requirements</td>
</tr>
<tr>
<td>14. Introduce/Learn New Technology</td>
</tr>
<tr>
<td>15. Probability of Project Completion</td>
</tr>
</tbody>
</table>
None of the criteria is dependent upon another, but some are related. For example, Response to Competitive Systems (9) might be associated with Support Explicit Business Objectives (7). Also, Probability of Achieving Benefits (11) might be associated with the Net Present Value criterion, by way of systematic risk assessment. Other criteria, such as Budgetary Constraint (6), might apply across the board to most projects. However, interviews with the 20 CIOs concerned showed that each criterion was of sufficient importance to be treated as a separate and distinct criterion for the purpose of the survey.

An important finding in developing the criteria was the need to distinguish between those IST projects undertaken in support of implicit business objectives, as opposed to those in support of explicit business objectives. In the prototype list of criteria, no distinction was made. However, it soon became evident that virtually all projects and investments in IST are, directly or indirectly, undertaken in support of implicit business objectives. For example, a significant machine upgrade might be undertaken due to volume constraints with existing hardware, and there may or may not be specific objectives attached to the upgrade. Essentially, it is a response to a problem. Presumably however, the project also provides support for basic business objectives (strictly speaking, aims or goals), such as profitability, increase in sales, etc. On the other hand, there may be investment in new or additional hardware as part of a specific plan and explicit business objectives. Thus, there is a basic difference between those IST projects or investments undertaken in support of implicit business objectives as opposed to those undertaken in support of explicit business objectives.

Another important finding was the need to separate into two parts the probability (and risk) of success (or non-success) relating to an IST project. Some organizations engaging in R&D recognize technical success, i.e., meeting all specifications and tests, as distinct from marketing success, i.e., the finished product selling well (Gaynor, 1990). In the field of information systems & technology, this is equivalent to Probability of Project Completion and Probability of Achieving Benefits. Probability of Project Completion concerns the probability of the project being completed according to time, cost, and quality requirements. Probability of Achieving Benefits relates to the probability and risk attached to the desired revenue flows and business effects. Such risk may be included in adjusting expected cash flows for risk. However, a number of companies indicated this as a risk that needs to be separately considered in today's turbulent business environment.

Lastly, the competitive environment is having an increasing impact on the selection of IST projects/investments, such that Response to Competitive Systems has become a further important criterion. Thus, an IST project may be undertaken to achieve a competitive advantage for the organization, or it may be undertaken in response to other organizations trying to do the same thing. A letter inviting participation in the survey, with the survey form enclosed, was sent to 72 publicly listed companies in Britain, 67 in the United States, 24 in Australia, and 40 in New Zealand for a total gross sample of 203 companies. The net total of usable replies (three were unusable) was 80, for a response rate (achieved after follow-up) of just under 40 percent. Of the 80 companies publishing a usable reply, 25 were American, 23 British, 11 Australian, and 21 were New Zealand companies. The reason for using these four countries was to obtain a wide experience of practice within a relatively common business environment.

There were originally 250 companies randomly selected from a library of around 2,500 current annual reports. A number of these companies were screened out because they were too small or because they did not appear to have, by the nature of their business, a significant investment in information systems & technology. This screening process reduced the number of companies to 203, to which the letter was sent. In terms of size, the 80 sample companies that provided a usable response to the survey are large organizations in which the IST investment decision (project selection) process and the criteria used are generally more structured than in small organizations (Doll and Torkzadeh, 1987). The breakdown of the sample by company size, in terms of annual sales, is shown in Table 2.

The industries in the sample represented a broad mix of different types of businesses. These are shown in Table 3, which uses the Datamation industry categories (Davis, 1989). Each of the 203 annual reports was studied to obtain, where possible, the name of the most appropriate senior management person able to pro-
Table 2. Number of Survey Responses by Company Size (Annual Sales)

<table>
<thead>
<tr>
<th>Annual Sales (in millions of U.S. Dollars)</th>
<th>No. of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 99</td>
<td>11</td>
</tr>
<tr>
<td>100 - 499</td>
<td>11</td>
</tr>
<tr>
<td>500 - 2,499</td>
<td>17</td>
</tr>
<tr>
<td>2,500 - 9,999</td>
<td>30</td>
</tr>
<tr>
<td>10,000 plus</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>

Table 3. Survey Responses by Industry

<table>
<thead>
<tr>
<th>Industry or Type of Company</th>
<th>No. of Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and Beverage</td>
<td>11</td>
</tr>
<tr>
<td>Industrial and Automotive</td>
<td>10</td>
</tr>
<tr>
<td>Banking and Finance</td>
<td>8</td>
</tr>
<tr>
<td>Electronics</td>
<td>6</td>
</tr>
<tr>
<td>Insurance</td>
<td>5</td>
</tr>
<tr>
<td>Retail</td>
<td>5</td>
</tr>
<tr>
<td>Petroleum</td>
<td>4</td>
</tr>
<tr>
<td>Metal and Metal Products</td>
<td>3</td>
</tr>
<tr>
<td>Transportation</td>
<td>2</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>2</td>
</tr>
<tr>
<td>Process Industries</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>

Survey Results

Completion of column 1 on the survey sheet answered the first question in the survey, which was:

Excluding routine maintenance work, which of the following criteria do you use in making the basic go-ahead decision on systems development projects and computer hardware or software facilities?

Completion of column 2 on the survey sheet answered the second question in the survey, which was:

What is your estimate of the number of projects to which a given criterion applies as a percentage of the total number of projects?

The survey results in answer to these two questions provided: (1) the percent of companies that use a given IST project selection (investment) criterion, and (2) the average percent of projects to which a given criterion is applied for those companies using the criterion. This is shown in Table 5.

For example, 68 percent of the companies indicated that they use budgetary constraint (on at least some of their projects) as one of their criteria in deciding on IST projects/investments. As a further example, 16 percent of the companies said that they use Average/Accounting Rate of Return as a criterion in selecting (at least some of) their IST projects.

In response to the second question the results indicate, for example, that those companies using Net Present Value as a decision criterion apply it, on average, to 58 percent of their projects.

The percent application of a given criterion for all projects in all companies in the sample, including those companies not using the criterion, can be determined by multiplying the criterion usage percent in Table 5 by the application percent. For example, the Net Present Value method is applied to only 28 percent (0.49 x 0.58), of all projects across all companies in the sample. Support of Explicit Business Objectives is applied to 50 percent (0.88 x 0.57) of all projects. Also, the

Table 4. Survey Responses by Job Title

<table>
<thead>
<tr>
<th>Job Title</th>
<th>No. of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief Information Officer</td>
<td>29</td>
</tr>
<tr>
<td>Information Systems (IS) Manager</td>
<td>20</td>
</tr>
<tr>
<td>IS Planning Manager</td>
<td>12</td>
</tr>
<tr>
<td>Chief Financial Officer</td>
<td>10</td>
</tr>
<tr>
<td>IS Controller</td>
<td>7</td>
</tr>
<tr>
<td>Chief Executive Officer</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>
Table 5. Usage and Application of a Given IST Investment (Project Selection) Criterion

<table>
<thead>
<tr>
<th>Criteria</th>
<th>% of Companies Using the Criterion</th>
<th>% of Projects to Which Applied by Companies Using</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial Criteria</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discounted Cash Flow (DCF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Net Present Value</td>
<td>49</td>
<td>58</td>
</tr>
<tr>
<td>2. Internal Rate of Return</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>3. Profitability Index Method</td>
<td>8</td>
<td>47</td>
</tr>
<tr>
<td>Other Financial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Average/Accounting Rate of Return</td>
<td>16</td>
<td>47</td>
</tr>
<tr>
<td>5. Payback Method</td>
<td>61</td>
<td>51</td>
</tr>
<tr>
<td>6. Budgetary Constraint</td>
<td>68</td>
<td>64</td>
</tr>
<tr>
<td>Management Criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Support Explicit Business Objectives</td>
<td>88</td>
<td>57</td>
</tr>
<tr>
<td>8. Support Implicit Business Objectives</td>
<td>69</td>
<td>44</td>
</tr>
<tr>
<td>9. Response to Competitive Systems</td>
<td>61</td>
<td>28</td>
</tr>
<tr>
<td>10. Support Management Decision Making</td>
<td>88</td>
<td>29</td>
</tr>
<tr>
<td>11. Probability of Achieving Benefits</td>
<td>46</td>
<td>63</td>
</tr>
<tr>
<td>12. Legal/Government Requirements</td>
<td>71</td>
<td>13</td>
</tr>
<tr>
<td>Development Criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Technical/System Requirements</td>
<td>79</td>
<td>25</td>
</tr>
<tr>
<td>14. Introduce/Learn New Technology</td>
<td>60</td>
<td>13</td>
</tr>
<tr>
<td>15. Probability of Project Completion</td>
<td>31</td>
<td>62</td>
</tr>
</tbody>
</table>

data show that only 40 percent of all projects in all the companies are subjected to some type of DCF method.

Completion of column 3 on the survey sheet answered the third question in the survey, which was:

What ranking would you give to each criterion in terms of the overall value of projects to which it applies?

The survey results in answer to the third question enabled a determination of the average ranking of each criterion based on the total value of projects to which the criterion is applied (for those companies using the criterion). This ranking is shown in Table 6.

For example, the results indicate that those companies using Net Present Value as a decision criterion ranked it fourth in importance (on average) in terms of the total value of projects to which it is applied. Support of Explicit Business Objectives was ranked #1.

Thus, the survey results show the percent of companies using a given criterion, the percentage of projects to which it is actually applied by those companies using it, and the ranking of each criterion in terms of total project value to which it is applied.

Financial criteria

Previous surveys on capital budgeting have found that discounted cash flow (DCF) techniques appear to improve the quality of capital budgeting decisions (Pike, 1988). An initial question in scrutinizing the survey results was, therefore, how many organizations use some form of DCF? The data showed that 75 percent use some form of DCF in selecting their IST proj-
Table 6. Value Ranking of IST Investment/Selection Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ranking by Total Project Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial Criteria:</strong></td>
<td></td>
</tr>
<tr>
<td>Discounted Cash Flow (DCF)</td>
<td></td>
</tr>
<tr>
<td>1. Net Present Value</td>
<td>4</td>
</tr>
<tr>
<td>2. Internal Rate of Return</td>
<td>2</td>
</tr>
<tr>
<td>3. Profitability Index Method</td>
<td>14</td>
</tr>
<tr>
<td>Other Financial</td>
<td></td>
</tr>
<tr>
<td>4. Average/Accounting Rate of Return</td>
<td>10</td>
</tr>
<tr>
<td>5. Payback Method</td>
<td>5</td>
</tr>
<tr>
<td>6. Budgetary Constraint</td>
<td>8</td>
</tr>
<tr>
<td><strong>Management Criteria:</strong></td>
<td></td>
</tr>
<tr>
<td>7. Support Explicit Business Objectives</td>
<td>1</td>
</tr>
<tr>
<td>8. Support Implicit Business Objectives</td>
<td>3</td>
</tr>
<tr>
<td>9. Response to Competitive Systems</td>
<td>6</td>
</tr>
<tr>
<td>10. Support Management Decision Making</td>
<td>7</td>
</tr>
<tr>
<td>11. Probability of Achieving Benefits</td>
<td>9</td>
</tr>
<tr>
<td>12. Legal/Government Requirements</td>
<td>13</td>
</tr>
<tr>
<td><strong>Development Criteria</strong></td>
<td></td>
</tr>
<tr>
<td>13. Technical/System Requirements</td>
<td>12</td>
</tr>
<tr>
<td>14. Introduce/Learn New Technology</td>
<td>15</td>
</tr>
<tr>
<td>15. Probability of Project Completion</td>
<td>11</td>
</tr>
</tbody>
</table>

...ects, with some companies using more than one criterion/technique. The corollary, however, is that 25 percent of these large organizations do not seem to use any form of DCF for information systems/technology investment decisions.

Net Present Value and Internal Rate of Return were ranked quite high, in terms of project value, by the companies that use these DCF criteria. However, the rate of application to their IST projects was moderate, being 58 and 54 percent respectively. This may indicate that NPV and IRR are only important in evaluating large projects.

The results indicate that the Internal Rate of Return (IRR) method may be more widely used in evaluating IST investments than Net Present Value (NPV), with 54 percent of the companies using IRR versus 49 percent for NPV. This is consistent with previous surveys of capital budgeting practice (Farragher, 1986; Pike, 1988). This finding may seem surprising given the theoretical superiority of NPV over IRR. The IRR method may, if used by itself, give misleading information in comparing projects of different size or timing in cash flows because the highest rate may not indicate the highest available return in actual/current dollars. There may also be more than one rate for a project whose net cash flows change from positive to negative and back again in different periods. Lastly, the IRR method implicitly assumes that net cash inflows can be reinvested at the same rate in succeeding periods, which is unlikely.

However, the difference between theory and practice in using IRR and NPV may be understandable in that (a) managers may be better able to identify with a rate of return for a project as opposed to a net present value, and (b) the NPV method predicates a (risk-adjusted) discount rate that may be difficult to determine (Butler and Schacter, 1989; Mills, 1988).
The Profitability Index Method (PIM), sometimes known as the Project Selection Index, is the least used of all criteria, being used by only 8 percent (i.e., six out of 80), of the companies surveyed. These few companies apply the criterion as a supplementary benchmark to NPV.

Overall, the moderate use of DCF techniques raises questions as to the extent of quantification in support of selection decisions on IST projects (even though quantification need not always be in financial terms). Quantification of estimated revenue flows or cash savings will not always be feasible. For example, it may be difficult to give reliable estimates of the added revenue that would accrue from improved customer service through a new online system. And quantified DCF benefits may be transcended by other criteria, such as the need to make quicker decisions or meet the level of service provided by competitors. However, the moderate use of DCF methods suggests that there may be some question as to whether quantification of cost vs. benefit, which is a basic aim of DCF, is being effectively attained in IST investment decisions.

Such techniques as Expected Value Analysis, Excess Tangible Cost, and Backfitting may be of some value in providing the numbers for quantification of cost vs. benefits (Rivard and Kaiser, 1989). Also, quantification becomes more feasible when there is an effective chargeback system in operation for the use of IST resources (Henry, 1990; McKinnon and Kallman, 1987). It becomes even more feasible when there is a benefit-tracking program in operation for IST projects, because there can then be feedback of cost and benefit information from prior to prospective systems investments. This process is shown in Figure 1.

For example, if a new system or technology improvement were thought to have a positive effect upon such an intangible as employee morale, this benefit might be broken down into quantified estimates of lower employee turnover, reduced absenteeism, reduced accidents, reduced wastage, higher quality, and repeat sales through improved customer service. In the case of improved customer service, variables such as waiting time, in-stock response, and frequency of sales/service calls might be quantified. In addition, the extent to which a new system/technology supports specific customer objectives and/or resource life cycle needs might be identified (Ives and Learmonth, 1984). The revenue estimates and associated costs might then be monitored, and future estimates could benefit through the data captured and learning gained from such prior projects. However, as illustrated in Figure 1, the process begins with specification of business objectives and concomitant quantification so there is something against which to track benefits and costs.

But even if quantification is considered feasible, management might not consider the effort worth the time and cost involved. This could be the case
when a systems project is mandated due to technical, legal, or competitive requirements. Or the project may not be considered large enough. Even in these cases, however, it would seem that a clear evaluation and tracking of cost vs. benefit would assist the formulation of current and future IST investment (project selection) policy through a better understanding and identification of IST-related benefits and costs.

However, if cost vs. benefit and DCF evaluation are to become easier and more generally used in the selection of IST investments, it will take more than DCF software to do it. There is, it would seem, a need to develop:

1. Discovery and quantification techniques that enable improved identification and assessment of strategic revenue benefits and cost savings in prospective IST capital projects/investments.
2. A methodology for identifying and quantifying the soft/indirect organizational costs.
3. Satisfactory financial evaluation techniques that address the rapid change and short-term needs of today’s business and IST environment.

All of this leads to the conclusion, based on the results of the survey, that there is a need for wider use of DCF criteria, and greater quantification, in IST investment decisions.

The Payback Method (PBK), a non-DCF method, is used by 61 percent of the companies in the sample (which is more than NPV or IRR). PBK ignores the time value of money, as well as any cash flow following the payback period. Also, there is no minimum rate nor any factoring for risk. However, two companies participating in the survey indicated that they use the Discounted Payback Method, which at least factors in a time value for money.

The continued use of the Payback Method and its implicit short-term orientation, notwithstanding its theoretical shortcomings, may have some justification. To begin with, it is easy to understand and use. Second, the complexity and difficulty in making predictions within today’s economic, political, and technological environments may lead some managers not to trust in long-term DCF projections; change in any one of these three areas could have a material effect on estimated cash flows. Third, in today’s business environment, change occurs so rapidly that time is compressed. Whereas 10 years was a long time “yesterday,” five years is a long time today. Fourth, in an environment of international corporate raiding and unfriendly takeovers, management may believe that the company’s stock market value needs to be kept high through a quick and reliable return on investment, the objective being to keep raiders and takeover merchants at bay.

Thus, the short term may well loom larger in the minds of managers than the long term, and the phenomena described may lead to a rapid-return focus. Therefore, a management orientation of two or three years becomes understandable, and so does the use of Payback as an IST investment criterion.

With respect to IST investments in particular, today’s technology may be obsolete in two or three year’s time. In addition, the general cost of computing power continues to decline significantly year by year (Horvath and Canham, 1988). Consequently, tomorrow’s technology may be cheaper than today’s. In such an environment, the use of the Payback Method, oriented to the short term as it is, may reflect nothing less than the “real world.”

Lastly, judging by the greater importance attached to NPV and IRR by those companies that use these criteria, it appears that PBK is used more as a “yardstick” in complementing NPV and IRR than as a primary measure, particularly in larger companies.

The Accounting Rate of Return method (ARR), like Payback, does not take into account the time value of money. However, it is evidently not used as widely as Payback (only 16 percent of the companies in the sample use it) and, even then, it is used largely as a yardstick measure in conjunction with DCF. Apart from being simple to use and understand, it has been said that one of the reasons for its continued use is that managerial bonuses are based on accounting rates of return (Weaver, et al., 1989).

The problem is that when the simple Payback Method or Accounting Rate of Return is used as the only financial criterion apart from Budgetary Constraint, rather than as a complementary yardstick to more rigorous DCF criteria, there may be grounds for concern as to whether there is sufficient justification and targeting of capital pro-
The financial criterion that figures mostly in IST project selection is that of Budgetary Constraint (i.e., "Did we budget for it?"). Of the companies surveyed, 68 percent use Budgetary Constraint as a project/investment approval criterion. It is applied by those companies that use it as a criterion to 64 percent of their projects. This is the highest application of any criteria. Thus, it is not applied to all projects, and this represents nothing less than the "real world," where it is not always possible to plan and budget for every IST capital expenditure. But such a high rate of application does seem to argue for the use of Budgetary Constraint, and the implicit IST capital budget, as a norm.

Since budgeting is complementary to the planning and control process, the moderate use of Budgetary Constraint as a criterion in IST investment projects (with 32 percent of the sample companies not using it), may indicate a need for improved planning and control in the use of IST resources in some companies. This inference is based on the observation that a capital expenditure budget is usually just "part of the picture" in overall (IST) planning (Weaver, et al., 1989). If there is no IST capital budget, there is little likelihood of a formalized plan.

On the other hand, Budgetary Constraint is ranked eighth in importance/value, out of 15 criteria, by those companies using the criterion. This may support a general principle of capital budgeting theory that all projects contributing to profitability should be accepted, whether budgeted or not, unless there is some strategic reason ruling out (current) acceptance. Thus, where a capital budget has been established for IST projects, that budget may be waived if a project offers a positive and reliable net present value, or if it supports some strategic corporate objective, or if it is a mandated "must-do" project.

Management and development criteria

Overall, Support of Explicit Business Objectives is the most important criterion used by companies in selecting IST investments/projects. This criterion refers to a given IST project or investment that supports business objectives specifically indicated in some sort of plan. In comparison, Support Implicit Business Objectives is a decision criterion justifying a project in accordance with business objectives/aims that are "understood," though not necessarily formalized, in any plan.

Most IST projects implicitly support basic business objectives (or goals). There is therefore a need to distinguish between those projects that support implicit (and generally basic) business objectives and those that have been specifically planned, or initiated, in response to a plan.

Support of Explicit Business Objectives is used as an IST investment criterion by 88 percent of those companies that participated in the survey. These companies apply it, on average, to 58 percent of their projects. It is also the top-ranking criterion, in terms of project value, in deciding on IST projects. Thus, Support of Explicit Business Objectives is clearly considered very important by those companies in the sample that have the experience of using it as an IST investment criterion.

In a business environment characterized by change and uncertainty it may not be possible to anticipate and plan every IST project. It may not be possible for every one to be initiated in fulfillment of one or more explicitly stated business objectives. There will always be a proportion of unplanned projects that are virtually mandated at short notice. However, in an increasingly competitive environment, is it necessary to knit together the objectives of the IST function with corporate and business-unit strategy in order to effectively utilize IST resources in sustaining competitive goals. As one survey respondent CIO commented, "If the IS department is in tune with the business objectives of the organization, the justification of a system is incorporated into the planning process, which includes justification of the total project expenditure at the macro level."

While it may not always be feasible to quantify the benefits of a prospective IST investment, such benefits can usually be represented in explicit corporate goals and objectives. If an IST investment is then directed toward the fulfillment of such goals and objectives, the raison d'être of the IST function has been satisfied, and quantified cost vs. benefit justification no longer dominates. As another survey respondent CIO...
said, "DCF is dominant, but any project has to visibly support business strategies and objectives. However, where rigorous DCF denies an obvious long-term benefit, then the DCF approach is set aside."

Some projects may neither be supported by a quantified cost vs. benefit analysis nor undertaken in pursuit of explicit (i.e., planned) corporate strategy or objectives. This is almost inevitable in a dynamic, complex business environment. However, it would seem that the aim should be for most projects to satisfy at least one of these basic criteria.

Response to Competitive Systems is used as a criterion by 61 percent of companies and is considered their sixth most important criterion. This is a criterion that may not have been relevant in past years. The fact that it is now indicates the significance of IST in today's competitive business environment. Another CIO commented that it is not so much a question of responding, i.e. reacting, as proacting: "We would express this criterion as systems to give competitive advantage, i.e., it is more important to keep ahead of the competition than to catch up with it!"

In some cases, Response to Competitive Systems may be the underlying criterion where an organization concludes that "we cannot afford not to invest" (as commented by another CIO). Without new information technologies there may be a serious loss in effectiveness and competitive standing compared to competitors that do invest in them (Johnston and Vitale, 1988).

It is not surprising that Support of Management Decision Making is used as a criterion by 88 percent of the companies that participated in the survey. This reflects the importance of systems in supporting management with requisite information. What may be surprising is that these companies apply the criterion to only 29 percent of their projects. In terms of project value, it is ranked only seventh in importance out of 15 criteria. Such ranking may be due to this "almost-traditional" criterion being transcended by other criteria as organizations mature to other emphases (such as competitive response) in the use of IST.

The criterion Probability of Achieving Benefits is a risk/probability criterion that is used by less than half (46 percent) of the companies who participated in the survey. However, it is possible that it has wider use than this in that it may have implicit inclusion in other financial or management criteria. Nonetheless, those companies that indicated use of the criterion apply it to an average 63 percent of their projects, which makes Probability of Achieving Benefits the highest proportion of any management criteria, second only to Budgetary Constraint in its percentage application to IST projects/investments.

Although Probability of Achieving Benefits might be implicitly included with other criteria, it may be a criterion that is best applied separately and distinctly because: (1) it represents a fundamental risk that is inherent in most projects in today's turbulent business environment, (2) it could provide for a more conscious management focus on and analysis of such risk, and (3) it would facilitate the learning process relative to this probability/risk.

Technical/System Requirements is a primary-level criterion, not a secondary-level, vendor-oriented criterion. The results show that it is used as an IST investment or project selection criterion by 79 percent of the companies that participated in the survey. This in itself is not surprising; such requirements are a necessity in most IST projects. For example, an organization may invest in an upgraded computer or network because it has outgrown the present configuration. Or a major re-write of a system may be required because it is no longer maintainable in its present form.

The issue with the Technical/System Requirements criterion is the degree to which it is used. In the survey and sample it is shown to apply, on average, to 25 percent of an organization's IST projects/investments. Where the proportion is significantly more than this average, it may indicate that the IST function and the organization itself is being driven by technical/system requirements rather than strategic objectives. That is, "the tail is wagging the dog." This may be the case where IST investments are effectively decided by "technology managers" and not "business managers" (Parker and Benson, 1988).

The criterion Introduce or Learn New Technology is one that, like the criterion Response to Competitive Systems, may not have been as relevant in past years. However, it is becoming more of a justification as information technology continues to grow in its impact upon business organ-
izations. Most organizations in the survey (60 percent) use it as a criterion, even though it applies to only a small proportion of their projects (13 percent).

Probability of Project Completion is a risk/probability assessment criterion that is used as an investment criterion by just under one-third (31 percent), of the organizations that participated in the survey. This might be considered a low proportion of companies given the high rate of failure of IST projects (McComb and Smith, 1991).

Those companies in the sample that do use Probability of Project Completion as a criterion apply it to 63 percent of their projects, which is the third-highest application of any criterion to IST projects. Thus, Probability of Project Completion is considered quite important by those companies that have the experience of using it in IST investment decisions. This supports research indicating that it is a risk/probability factor that needs to be part of any project evaluation (Spadaro, 1985; Willburn, 1989).

Summary and Conclusions

Business competition is global, intense, and dynamic. Information systems & technology (IST) is a key resource in responding to and proacting with this environment. Consequently, capital investment decisions in selecting systems projects and hardware/software acquisitions are of a critical nature within the organization’s overall strategy. The basic question is, therefore, how do organizations make these investment decisions, and how should they? In responding to that question, this study concentrates on the decision criteria, as opposed to the decision process.

Fifteen criteria were used—six financial, six management, and three development—in a survey undertaken in 1990 of 80 major companies in four countries: the United States, Britain, Australia, and New Zealand. The companies were asked to indicate which criteria they use, the percentage of projects to which each criterion is applied, and the overall ranking in terms of total project value for each criterion.

The results show that discounted cash flow (in the form of Net Present Value, Internal Rate of Return, and/or Profitability Index Method) is used as an investment criterion for IST projects by about 75 percent of the Fortune 500-type of companies that participated in the survey. Overall, DCF techniques are applied to only 40 percent of all projects in the sample, although it is evident that DCF is important in the evaluation of large projects.

Except for Budgetary Constraint, the Payback Method is the most widely used financial criterion. Budgetary Constraint itself is used by about two-thirds of the companies in the sample.

The highest-ranked criterion is Support of Explicit Business Objectives, and it is used as an IST investment criterion by nine out of 10 companies. It refers to projects that specifically support and tie in with business objectives articulated in company plans.

Response to Competitive Systems is used as an investment criterion by 61 percent of the companies in the sample, by whom it is ranked sixth out of 15 in importance. This reflects the increasing significance of information systems & technology in today’s competitive business environment.

Somewhat surprisingly, and although it is used as an investment criterion by nearly all companies in the sample, Support of Management Decision Making is only applied to about one-quarter of all projects and ranked seventh in importance by those companies that use it. This relatively low application and ranking may be due to Support of Management Decision Making being transcended by other criteria as organizations mature to other emphases in the use of IST.

There were two probability/risk assessment criteria included in the survey, namely Probability of Project Completion and Probability of Achieving Benefits. The completion criterion is used by one-third of the companies. The benefits criterion is used by about half of the companies.

The development criterion Technical/System Requirements is used by most companies in the sample. The remaining development criterion, Introduce/Learn New Technology, is used by the majority of companies, though it is only applied to about 10 percent of their projects.

Some of the general conclusions developed in the analysis and discussion of the survey results are prescriptive in nature. That is, based on the practice and experience of the 80 major com-
panies that participated in the survey, there appear to be a number of proposals that might be considered by organizations in making decisions on their IST projects and investments. These are as follows:

1. More accurate quantification of cost vs. benefit and more informed IST investment decisions are facilitated where there is effective benefit-tracking and chargeback in place.

2. The ideal is for an IST project or investment to be undertaken in pursuit of both: (a) quantifiable net benefits and (b) explicitly planned business objectives. Apart from mandatory (must-do) projects, the aim should be for at least one of these basic criteria to be involved in an IST investment decision.

3. The high application rate of Probability of Achieving Benefits, as an IST investment criterion by some companies, indicates that it may be sufficiently important to be formally considered as a distinct criterion in evaluating and deciding upon prospective IST capital investments.

4. If an organization wishes to gain access to the pertinent learning curve of new information technology likely to be of benefit, it may be necessary to regularly undertake some R&D funding by way of "seed money" for such projects and investments.

5. Probability of project completion is a risk/ probability criterion that is appropriate to consider as a decision criterion in evaluating and deciding upon IST projects/investments and is, in any case, an element present in most of them.

The underlying thrust of the study was and is toward application. The goal is to bridge the gap between practice and academia. However, these results, together with the analysis and proposals accompanying them, are only a beginning, or perhaps just a step along the way, in this key area of IST management decision making.

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**About the Author**

C. James Bacon is senior lecturer in information systems at the University of Canterbury, Christchurch, New Zealand. He previously worked as a systems consultant in London and New York. His research is in the management of information systems, with an emphasis on "bridging the gap" between practice and academia.
Information Systems/Technology Investment Criteria

Net Present Value (NPV) is a discounted cash flow (DCF) method in that it takes into account the time value of money. A specified rate of return is used (which might be called the cost of capital or the "hurdle rate") to discount all cash flows for a project, both investment and expense outflows and revenue inflows, in order to value those cash flows as of time zero, i.e., the beginning of the cash flows (generally the point of initial investment outlay). The discounting process is usually done with the aid of present value tables or equivalent software. If the resulting Net Present Value is positive (i.e., the present value of the inflows is greater than the present value of the outflows), then the go-ahead might be given for the project/investment.

Internal Rate of Return (IRR) is also a DCF method. However, compared to the Net Present Value method, there is no directly specified rate of return. Instead, the objective is to find the rate of return for a project or investment, based upon the cash flows and respective time periods, that makes its net present value equal to zero. (Finance textbooks generally consider the IRR method to be inferior to the NPV method.)

Profitability Index Method (PIM) is a third DCF method. When it is based on the Net Present Value method, it provides comparative profitability among different projects or investments by dividing the present value of the future cash flows of a project by its initial fixed investment. When it is based on the Internal Rate of Return method, the higher the rate of return the better the project.

Average or Accounting Rate of Return (ARR) for a project or investment is found by dividing the average annual income after tax over the life of a project by the initial fixed investment. It is not a DCF method.

Payback Method (PBK) is a further non-DCF method. It estimates the time required to recover the initial investment, i.e., how quickly a project or investment will pay for itself. The estimated net cash flows for each year are added until they total the initial investment. The time required is the payback period; the shorter it is the more preferable the project. There is also the Discounted Payback Method, which takes the time value of money into account: each year’s estimated net cash flow is discounted at the required rate of return, and the resulting present values are added until they total the initial investment.

Budgetary Criteria or Constraints apply where project/investment go-ahead is subject to or influenced by pre-established funding allocations.

Support Explicit Business Strategy or Objectives applies where a systems project or investment is given the go-ahead to fulfill business strategy or objectives that are articulated in some sort of plan, generally a corporate or business-unit plan.

Support Implicit Business Strategy or Objectives is the justification where a system project or investment is given the go-ahead in recognition of business objectives/aims that are “understood” though not necessarily formalized/articulated in any plan.

Response to Competitive Systems is the justification when a project is initiated in direct or indirect response to the competition adopting, or appearing likely to adopt, new information systems and/or technology (IST) that is likely to bring about increased competitive pressure. It may also be the justification in a proactive sense, i.e., seeking competitive advantage through the use of IST.

Support Management or Executive Decision Making is the main criterion when an important part of the project’s justification is enhanced information for enabling more informed, more rapid, or easier management decision making, and/or enhanced communication.

Probability of Achieving Benefits relates to the probability (or risk) of the planned project achieving (or not achieving) what it is intended to achieve in terms of its benefit and/or business effects. The factors and assumptions involved in this type of criterion might be included in a business analysis of the project.
Legal or Government Requirements is the justification when a project or hardware/software investment is undertaken primarily to meet government regulations or legislation, as for example with taxation or reporting requirements.

Technical/System Requirements applies when hardware or software requirements are a major factor or need in going ahead with the project as, for example, with system re-writes or machine conversions/upgrades.

Introduce or Learn New Technology applies when an organization introduces some new form of information technology, or a new concept in systems, for the purpose of gaining experience or expertise in that technology or concept, with a view to its probable use within/by the organization.

Probability of Project Completion is a criterion employed in assessing the probability (or risk) of the project being completed (or not being completed), according to time, cost, and quality requirements. This would include the following type of factors:

- Project size
- Technical innovation
- Definitional uncertainty
- Complex organizational integration requirements
- Life-or-death deadline
- Experience and ability of personnel
- Availability and dependence upon personnel
- Senior management support
- User participation

The last two factors, namely senior management support and user participation, may not be fully known in advance, that is, at the point when criteria are being evaluated and exercised.

Appendix B

Survey of Project Decision Methods

Excluding routine maintenance work, which of the following methods, criteria, or justification does your organization use in making the basic go-ahead decision on system development projects and computer hardware or software facilities? Please tick them off as applicable in column 1, and please complete column 1 before going on to column 2. Also, it may be best to use a pencil in case of changes.

Next, what is your estimate of the number of projects to which a given method applies as a percentage of the total? Indicate this in column 2. Your best estimates will be sufficient.

Lastly, in column 3, what ranking would you give to each method in terms of the overall value of projects to which it applies? Start with most important = 1, next in importance = 2, etc.

All information from your completed survey sheet will be held strictly confidential, and the overall results will be sent to you.

Explanatory Notes giving detailed explanations are attached.
Explanatory Notes giving detailed explanation are attached.

<table>
<thead>
<tr>
<th>Methods/Criteria/Justification</th>
<th>1. Tick</th>
<th>2. Percent of projects to which applied</th>
<th>3. Ranking</th>
</tr>
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<td>(a) Net Present Value</td>
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<tr>
<td>(b) Internal Rate of Return</td>
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<tr>
<td>(c) Profitability Index</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(d) Other</td>
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<td>2. Non-DCF Financial:</td>
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</tr>
<tr>
<td>(a) Average/Accounting Rate of Return</td>
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<tr>
<td>(b) Payback Method</td>
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<tr>
<td>(c) Other</td>
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<tr>
<td>4. Support of Business Strategy/Objectives:</td>
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<tr>
<td>(a) Explicit</td>
<td>✓</td>
<td>60</td>
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<tr>
<td>(b) Implicit</td>
<td>✓</td>
<td>50</td>
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<tr>
<td>5. Response to Competitive Systems</td>
<td>✓</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>6. Support Mgt./Exec. Decision Making</td>
<td>✓</td>
<td>30</td>
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<tr>
<td>7. Technical/System Requirements</td>
<td>✓</td>
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<tr>
<td>8. Legal or Government Requirements</td>
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<tr>
<td>9. Introduce/Learn New Technology</td>
<td>✓</td>
<td>10</td>
<td>11</td>
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<td>10. Project Risk or Probability of Project Success:</td>
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<tr>
<td>(a) Completion of Requirements</td>
<td>✓</td>
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<tr>
<td>(b) Achievement of Benefits</td>
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<tr>
<td>11. Other (please specify):</td>
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<tr>
<td>(a)</td>
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<tr>
<td>(b)</td>
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<tr>
<td>(c)</td>
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